A QUARTERLY JOURNAL OF METHODS AND INFORMATION FOR TEACHERS OF SCIENCE

121

The SCIENCE COUNSELOR

Volume XIX ⋆ Number 2 ⋆ June, 1956

DUQUESNE UNIVERSITY PRESS

The Science Counselor

"FOR BETTER SCIENCE TEACHING"

A QUARTERLY JOURNAL *of teaching methods and scientific information especially for teachers of science in Catholic schools. Indexed in the Catholic Periodical Index. Published at Duquesne University, Pittsburgh, Pennsylvania, in March, June, September and December by*

DUQUESNE UNIVERSITY

Subscription Price: $2.00 per year; Canada, $2.25. Single copies of issues in the current year, 60¢ each. Business and Editorial Offices at Duquesne University, 901 Vickroy Street, Pittsburgh 19, Pa.

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Requiescat in Pace

HUGH C. MULDOON

Founder of THE SCIENCE COUNSELOR; Founder of The School of Pharmacy of Duquesne University; Officer of the National Science Teachers Association; Past President of The American Association of Colleges of Pharmacy.

HUGH CORNELIUS MULDOON died at the home of his sister Mary W. Muldoon in Waverley, New York, Friday morning May 4, 1956.

Three months ago he entered the Mercy Hospital in Pittsburgh. It was learned at that time that his illness was fatal. He returned to his sister's home where, with full knowledge of his condition, he died quietly.

"The Dean" came to Duquesne University in 1925 from Valparaiso University. He organized and guided the School of Pharmacy from its inception until his retirement in June of 1955. He resigned because he appreciated the fact that the pace he had set for the College was too severe for his physical condition. This decision gives an insight into his personality — He accepted nothing less than the best from his students or from himself.

From its beginning the college was accepted nationally as comparable to the finest colleges of pharmacy in the United States; this was due to his intelligent guidance, his tireless efforts and his kindly but firm leadership.

He exemplified an interesting phenomenon, in that he devoted most of his waking hours to his Deanship oblivious of honor, and yet honors were bestowed upon him most graciously.

HIS STUDENTS established The Hugh C. Muldoon Foundation.

HIS COLLEAGUES conferred on him the Remington Medal.

HIS UNIVERSITY conferred the Degree of Doctor of Letters.

HIS COUNTRY selected him as one of five important persons to study the educational facilities of Japan in relation to pharmacy.

During his career at Duquesne "The Dean" was administrator of the College of Pharmacy, taught classes, interviewed prospective students, kept the editions of his books up to date, founded and edited THE SCIENCE COUNSELOR, traveled extensively to scientific meetings, contributed to the United States Pharmacopeia and last but not least he always maintained a close personal relationship with his former students.

"Dean" was a scholar, an educator, a gentleman and a devout Catholic.

We shall miss him, but his benevolent influence shall live forever.

DR. LEO D. O'DONNELL
MERCY HOSPITAL, PITTSBURGH, PA.
MAY 5, 1956

Power from the Atom

• **By James Stokley, M.A.,** *(University of Pennsylvania)*
NEWS BUREAU—GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

Will atomic power replace conventional fuels?

This article discusses the scientific, economic and technical feasibility of the commercial distribution of electrical power from an atomic-powered plant.

You will enjoy reading this highly informative article.

During recent months the newspapers have frequently referred to "The Geneva Conference." To the diplomat, or the student of international affairs, this obviously means the "Summit" conference, held in Geneva, Switzerland, last June, or that of the foreign ministers in October.

But mention "The Geneva Conference" to many scientists and engineers, and they think immediately of another meeting held in the same city last August. This was the International Conference on Peaceful Uses of Atomic Energy, sponsored by the United Nations, at which more than 1200 delegates, from 72 nations, heard 474 papers on practically all phases of atomic energy — all except those concerned with military applications. So successfully was information shared among the nations that future historians may well regard it as the more important of the conferences held in Geneva in 1955. Plans are well under way for another such conference in a few years.

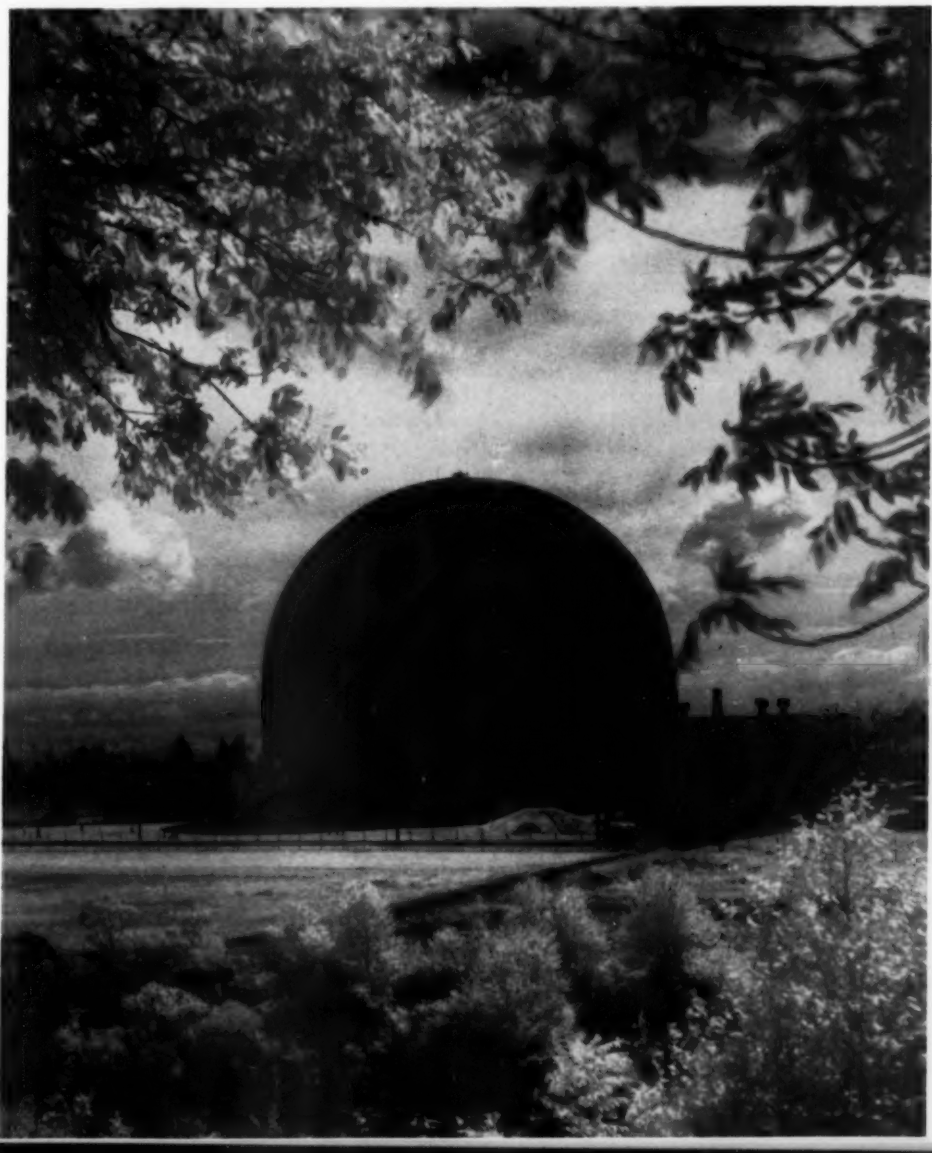
Geneva made more evident what was already apparent to those intimately concerned with applying atomic energy that atomic power is much nearer than had been supposed until quite recently — in fact, it is already here!

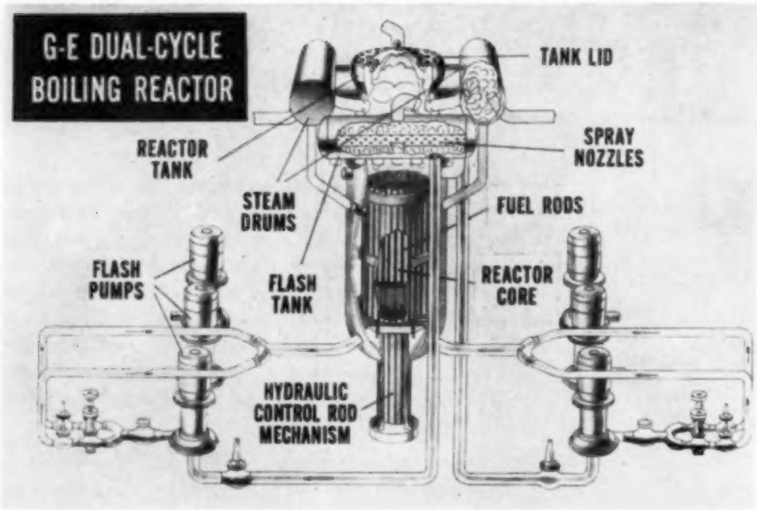
In 1945, when wartime work on the atom bomb was revealed, many rosy predictions were made — about automobiles equipped with an "atomic pill" that would make it unnecessary ever to stop at a filling station; ocean liners that would cross the Atlantic on a teaspoonful of fuel; or atomic heat for our homes that would be practically free. With more sober thinking there was a swing toward the other extreme. Atomic energy conceivably could be applied to heating homes, driving ocean liners, or providing power for cities, we were told, but it was still expensive. It would probably be a long time before such applications became widespread.

But now, a number of plants are actually in use yielding practical experience. As a result of careful and detailed studies by engineers and scientists, a middle position has been reached. Already, in some areas, nuclear power seems economically feasible. In England, for example, where the coal reserves that kept the economy operating during the past century have now been largely depleted, atomic energy will be able to supply much needed power. An extensive program of building such plants is under way, with operation scheduled to start in 1956.

The first actual generation of electricity from atomic energy took place at the Atomic Energy Commission's testing station at Arco, Idaho, in December, 1951. At

ATOMIC AGE—Like the colossal remains of an ancient civilization, this steel sphere dominates the countryside around West Milton, N. Y. Here the General Electric Co. produced the world's first commercial atomic electric power for use in homes and industries. Inside 200-foot diameter ball is prototype reactor for Navy submarine "Seawolf." Excess power from the reactor was used to turn a G-E turbine-generator, and generate commercial e'ectric power.





A-Power—General Electric's dual-cycle boiling reactor is of new design that ups the output-per-size several times over the direct boiling reactor. Water circulates up from bottom of main pressure vessel through reactor core and is turned into steam. Flash tank furnishes additional steam to turbine-generator, and supplies water to reactor. This reactor will power a generating station G.E. will build for the Commonwealth Edison Co. of Chicago.

that time a reactor, designed by the Argonne National Laboratory, generated about 200 kilowatts of electrical power, which was used to light the building and operate machinery. In February, 1953, a reactor at the Oak Ridge National Laboratory, in Tennessee, produced electricity, at about the same power, and in June of the same year electricity was generated from the prototype, at Arco, of the reactor for the first U. S. atomic submarine, the Nautilus. Early in 1954 the vessel itself was commissioned, and another atomic power plant was in operation.

In the meantime, at West Milton, N.Y., another reactor — the prototype of the power plant being built for the second atomic submarine, the Seawolf, by the General Electric Co., was being completed, and went into operation in the spring of 1955. On July 18, electrical power generated by this installation was fed into the lines of the Niagara Mohawk Power Corp., the first production of electricity for commercial distribution through a utility company in this country.

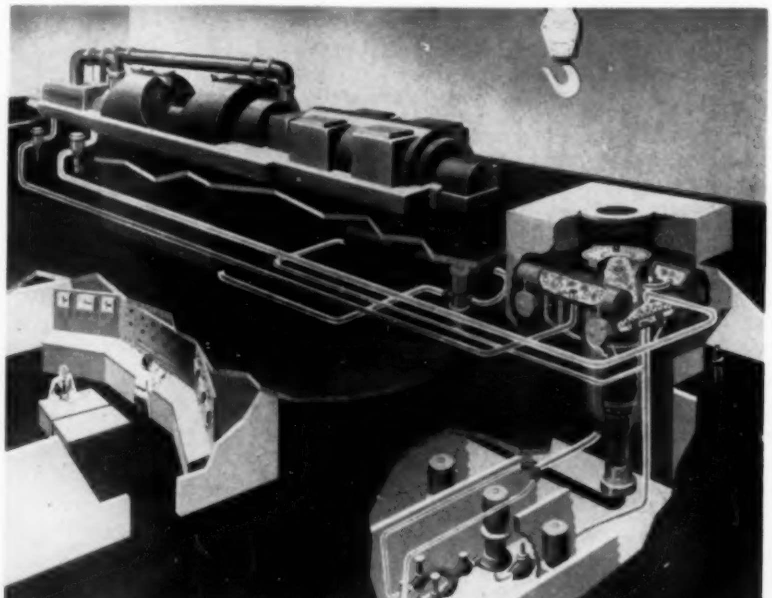
Outside the United States, the first production of atomically produced electricity seems to have been in a Russian plant, near Moscow. According to a paper presented at the Geneva Conference, this started up on June 27, 1954, producing 5000 kilowatts.

From all this it might seem that atomic energy is something new, but it is a fact that in the past the world has never used anything but atomic energy!

No matter whether energy comes from the burning of wood, coal, or oil; or from water power, its ultimate source is the Sun. In the case of water power, this is quite obvious, for we all know that the heat energy from the Sun causes evaporation of water in the oceans, lakes and rivers. The vapor is carried aloft, and eventually condenses and falls as rain on higher ground. As it finds its way back toward the ocean, it may drive turbines and so generate electricity derived from solar energy.

Other forms of power likewise depend on the Sun. As a tree grows, it collects solar energy in the process of photosynthesis, by which it builds itself up from the raw materials of carbon dioxide and water. Thus, energy released when wood is burned is derived from the Sun. Since coal is the fossil remains of vegetation, its energy came from a similar source, millions of years ago. Oil is derived from organisms of past ages, which likewise obtained energy from the Sun while they lived. The source of solar energy (and also that of other stars) is an atomic one, whereby four nuclei of hydrogen atoms are combined to form one of helium. As this occurs, a little mass is lost, and turned into energy. This is the process that has been the origin of all energy used on the Earth in the past.

Man has now attained at least partial control over the solar process, since he has learned to use one closely related to it as a weapon, in the form of the hydrogen



Atoms At Work—An artist's conception of a new 180,000 kilowatt dual-cycle boiling reactor shows it coupled to a turbine-generator for a utility power plant. Water is boiled directly inside the reactor (right) to produce steam for the turbine-generator (upper left). G.E. will construct the giant unit—the largest yet scheduled—for the Commonwealth Edison Co. of Chicago. This type of reactor has a power-per-size ratio several times better than the direct boiling reactor.

bomb. Whether it can be tamed sufficiently to be used as a source of power is very uncertain but an intensive study of the possibilities, sponsored by the U. S. Atomic Energy Commission, is being made in several different laboratories. As Lewis L. Strauss, Chairman of the AEC, said in announcing this project:

"It cannot be stressed too strongly that, based on what we now know, we are far from a solution of the problems of the controlled fusion reaction. Our work is in the research stage and many years of intensive effort may be required before the first prototype of an operating thermonuclear machine may be developed."

There is, in fact, no certainty that the problem will ever be solved. The course of wisdom, therefore, demands that we proceed as rapidly as possible with the development of what might be called "conventional" atomic power, in order to meet the ever-increasing needs of the world for energy.

That such needs exist has been shown clearly in an exhaustive study made for the AEC by an engineer, Palmer Putnam. Making use of a unit he calls "Q," equivalent to one quintillion British Thermal Units, or nearly 300 trillion kilowatt-hours, he has determined that the whole world is now using about a tenth of a Q per year. Up to now it has used a total of about 12-13 Q. But our use of power is rapidly increasing, on account of a constant increase in population, and also in the per capita power demand. By the year 2000, Putnam estimates, the world will use one Q each year, and will have consumed an aggregate of 30 Q.

How much energy remains in the ground, in the form of coal, oil, gas and shale from which oil may be extracted? Even allowing for a doubling of present costs, it seems that what remains cannot contribute more than 40 Q, he says, which means that in about a century there will be no more reserves of economically useful fossil fuel.

Something like 20,000,000 tons of coal must be burned to deliver one Q of heat, but this can be obtained from only 14,000 tons of uranium, provided it goes completely through the fission process. Thorium also is a possible atomic fuel, and it is estimated that there are some ten trillion tons of these two elements in the Earth's crust, to a depth of three miles.

Much, of course, is in ores of too low a grade to be of value, but Putnam estimates that there are 25 million tons of uranium and 1 million tons of thorium which can be extracted at a cost of not more than $100 per pound, allowing for reasonable technological advances. Assuming that only a third of this amount can be utilized, he concludes that there is still enough to yield 624 Q of energy, which would keep the world's machinery in operation for a long time after fossil fuels have been exhausted.

As found in nature uranium consists mainly of two kinds, or "isotopes." Each atom of the most abundant kind has a mass of 238 units on the physicist's scale; the other, which makes up about 1/140th of the total, weighs 235 such units. If the nucleus of one of these atoms is hit by the atomic particle called a neutron, it may be split into two lighter nuclei. At the same time, additional neutrons are shot out; these may split other U-235 nuclei, providing still more neutrons to split more U-235 nuclei and so on, thus making possible a continuous chain reaction.

The pieces produced by the splitting, or "fission," fly apart with great speed. If they are slowed or stopped their energy of movement is converted into heat. Thus, the nuclear reactor, where this process takes place, is the furnace that provides heat in an atomic power plant. The heat so produced is used, just like the heat from burning coal or oil, to generate steam which, in turn, drives a turbine that turns a generator, producing electricity.

From the intense activity inside the reactor there come many kinds of radiation, similar to those given off from radium and other radioactive substances. These are alpha particles (which are nuclei of helium atoms), beta particles (electrons) and gamma rays (high-energy X rays). Also there are neutrons, some left over from the fission process, some produced by gamma rays as they strike materials in the reactor.

Alpha and beta particles are easily absorbed, but gamma rays and the neutrons are very penetrating and dangerous to life. Thick and heavy shielding must surround the reactor to protect personnel. Materials introduced into the reactor likewise become radioactive—and potentially dangerous if not handled properly. If water is so admitted, the steam into which it is converted by the heat of the fission process likewise becomes radioactive.

For this reason most power reactor designs have made use of a second stage in generating steam. Some fluid, perhaps water under pressure to raise its boiling point and so permit it to carry more heat; liquid sodium; or even air, is heated in the reactor. Then it goes to another unit, called a heat exchanger, where it is used to heat water and turn it into steam, which is not radioactive and may be piped freely to turbines and other places where it is used. The heat exchanger, as well as the reactor itself, and the piping connecting them, would all be shielded.

The reactor at Arco, Idaho, with which electricity was first generated from atomic energy in Dec., 1951, uses a molten alloy of sodium and potassium (NaK), in the heat transfer process. In fact, there is a double system. The liquid that passes through the reactor goes to a heat exchanger, where more NaK is heated, and this in turn goes to the boiler to generate steam.

The power plant for the Seawolf, like its prototype which has been generating electricity at West Milton, N. Y., will make use of liquid sodium as a coolant. Pressurized water is employed in the Nautilus, and also in the atomic plant being built, under the auspices of the AEC, by the Westinghouse Electric Corp. for the Duquesne Power & Light Corp. at Shippingport, Penna.

Still a different scheme is that employed in the "Homogeneous Reactor Experiment," at Oak Ridge, where the production of electricity from atomic energy for the second time was accomplished early in 1953. Most reactors are "heterogeneous," that is, the uranium

(Continued on Page 70)

Comical or Chemical Education?

• By W. G. Kessel
ASSOCIATE PROFESSOR OF CHEMISTRY, INDIANA STATE TEACHERS COLLEGE, TERRE HAUTE, INDIANA

Constant self-evaluation is the key to effective teaching.

The teacher who carefully prepares his classes and keeps up to date in his subject frequently fails in effectiveness because of personality traits, mannerisms, or qualities of voice which amuse, annoy or otherwise distract his students.

The author in a good-natured and searching manner discusses some of the errors into which chemistry teachers frequently fall.

This article will appeal to serious teachers of all subjects.

●

"Hmm - - - - - eh - - - ah - - - uh - - - and uh - -"

"That's the 15th time he has scratched his nose in 15 minutes which is near a new record."

"Do you suppose that holey blue serge is his only suit?"

"I'll bet you four bits he canters around that demonstration desk at least 25 times this hour." "You keep score."

"Why, oh why does he fiddle with his glasses, taking them off, twirling them, putting them on - - - ad infinitum ad nauseam?"

"If he says '- - - -,' again I'll scream."

How many times in your student career have you made, or heard others make, such statements as these, if you give or take a few words? Maybe they did not detract from the instructor's ability to teach but probably those annoying mannerisms are the only thing you recall from Professor X's course. Are you unknowingly doing the same thing for your students?

Today critics of educational procedure and philosophy have pointed an accusing finger at everything from agriculture to zoology in a vain attempt to analyze the school's inability to get accomplished the things they feel are important. If you are a high school teacher, a most ethical and professional individual, the odds are high that you have made some disparaging remarks about the previous preparation and schooling of your pupils. Sad as it is to relate, such a statement is equally true for the college and university instructor. He too often feels that the passing parade of students are woefully inadequate in their ability to do the job he has for them.

May we add that this same instructor may actually be perpetuating this condition. Some of his pupils, who hope to teach, are themselves becoming part of this vicious cycle; poor teacher and poor teaching yielding poorer teacher and poorer teaching etc.

Some educational institutions have evidenced consternation over this situation and are trying to do something about it. Quite a number of them formerly felt that the high school chemistry teacher should do identically the same graduate work as the potential Ph. D. who is going into research. Some of these insitutions are developing tailor-made courses in chemistry that can really help the secondary teacher.

The old style "buck passing," if allowed to continue, can finally place the blame on the kindergarten teacher who will only have one recourse, blame the parents. Doubtless in this era of specialization some wag will want to know, which one?

Today we chemistry teachers must accept some of the blame for the widely heralded shortage of chemical personnel. Naturally we have an aversion to admitting our shortcomings, especially since the public is finally arousing from its educational lethargy. If we are as honest in this analysis as we would be if we ran it in the laboratory we must face this responsibility.

Are you, as a chemistry teacher, doing the best possible job in your institution in interesting young men and women in the multiplicity of jobs and professions which are dependent upon chemistry? The field of guidance has become a specialized endeavor and trained individuals are helping to plan the educational and professional future of our youth. Do you leave this job in the specialists hands? With all due respect to this educational development there are many who do not know very much about chemistry, may have no interest in it or any concept of its tremendous potential. If the guidance men or women omit chemistry then who but you, the chemistry teacher, can enlighten the student?

Recently the writer's daughter was being counseled in a local junior high school by a teacher assigned this task and she did a good job. But Janie said "Daddy, Miss ——— told Carol and Mary, who want to take nurses training, not to take science." This came because she had heard me moan and groan at home about the inadequate science experience on the part of student nurses in our college. Miss ——— was sincere but she just did not know. Now there are some specific strongly worded suggestions in the guidance literature of our city schools in regard to the inclusion of science in the potential nurses high school program.

The high school chemistry teacher should have, in this day of automation, a constant recording, analyzing, and inventorying device so that he can see where he has been, what he has done, and where he missed the objective. Chemistry is a most moving dynamic endeavor and it is imperative that its teaching be done

in a forceful dynamic fashion. If and when chemistry teaching becomes routine and static it is of doubtful value.

In order to pin point your thinking on some of the areas where teachers can do something let us examine the following.

Mannerisms

Any personal behavior which attracts the student's attention will likely detract from his concentration on the subject at hand. Recently institutions that used closed circuit TV found that the "pacing" instructor could not be kept "on camera." These men had never realized how much territory they actually covered in the lecture room.

Do you scratch your ——— (fill in your own itching area) with disconcerting regularity? How about gazing out the window, fondling a meter stick or class cards, rocking back and forth, and even patting your curls or the lack of them?

Some of these mannerisms may have become so ingrained in your behavior that you will have to have help in identifying them. Think about it during the next class period and chuck them out.

Voice

Do you lull your students to sleep with a low, soft monotone? Perhaps your strident voice is most irritating. You have heard both kinds and are aware of the animosity created by them. The teacher cannot afford to use either.

Subject Matter

Are you bound so closely to the text that the student dare not introduce anything else for fear of being out of bounds?

The development of student interest and enthusiasm in chemistry should be no problem if one can see beyond the text. Excellent information on all phases of chemistry and its role in our world is available from a multitude of trade journals, society periodicals, popular magazines, industrial and trade advertising and public relations brochures. The biggest problem lies in selection and organization of student usable information.

Surely you impress your pupils with the realization that chemistry is not a static thing which occurs in room 301, five days a week at 9:45 A. M. That it has top billing in all of their activities and that they will find it very difficult to name an area where no chemistry is involved.

Since the author taught high school chemistry for some years and now is a consumer of these products, he is most aware of the fact that the secondary school teacher must create and develop interest and enthusiasm for chemistry. Such was the case with most of us and a show of hands at any chemistry meeting, industrial or educational will bear out the fact that the high school chemistry teacher was the most potent factor in their decision for chemistry as a vocation. Are you stimulating others to work in this field?

The text should not be the limits for chemistry and neither should the teacher lack in originality in attacking the miscellaneous teaching problems he faces.

Organization

Understanding can only occur when students are taught in a logical organized fashion. A hodge podge of unrelated and isolated facts, theories, laws, principles, and hypotheses are of little value to the beginning student. Chemistry is such a tremendous field that the instructor will of necessity have to cut and delete using his own best judgment but he must keep it well organized.

Personality

How do you feel about your pupils? Are you really interested enough in their welfare to show it by being gracious about their requests. Are you willing to digress if a sincere question arises that is not in the planned lesson for the day? Are you so enthusiastic about the field of chemistry that it shows? Remember you are a salesman, perhaps the only salesman of this field that John or Mary will ever meet and your actions may enroll individuals in chemistry as a vocation or make them loathe it.

An article by William Locke[1] points out the loss of an estimated $200,000 and five years of arduous work by research engineers because they could not read an article on this field in the Russian language. Are you raising a barrier before your students by personality conflicts or by using language and behavior that is as foreign to them as Russian?

Enjoyment

Are you getting a "kick" out of your teaching? Happy, enthusiastic stimulating teachers stand out like lighthouses on a dark night as you review your educational experiences. Our main regret is that there were so few of them. Are you illuminating the dark rock bound coast of chemistry?

If you are dragging, tired, lack lustre, awaiting-for-the-paycheck type individual, you should do something about it. Today there are available many shots-in-the arm for not only these individuals but for all chemistry teachers. Try for a summer industrial job, a conference, an institute, a work shop, or a fellowship today. These are designed to help you and the stimulation is marvelous. If you are a pessimist you may even find other teachers who have jobs worse than yours.

If we as chemistry teachers, at all levels, are willing to do some bits of research on our own problems of teaching technique and procedures then individually we can do much to help the present shortage of personnel.

Are you doing comical or chemical education? ●

1. William N. Locke, "Translation by Machines," The Scientfic American Volume 194, Number 1, page 29, 1956.

Plan A Field Trip With Industry

• By Flora G. Dowler, B.S., *(Ohio State University)*
MEMBER, EDUCATIONAL SERVICE BUREAU, AMERICAN GAS ASSOCIATION, 420 LEXINGTON AVE., N. Y. C.

Here is a procedure for teachers to follow when planning an industrial field trip.

Teachers should not overlook the educational opportunities offered by local industries. However, field trips should be planned well in advance.

One industry that is most willing to cooperate with teachers and is easily accessible to all schools is the local gas company.

●

The field of Science is expanding so rapidly these days that it is difficult for educators and text book authors to keep abreast of all the developments. Industry is in a position to provide up-to-date material for our teachers, with the assistance and approval of leading educators in the field of Science.

Basic fundamentals in the field of Science have not changed too much, but the application via new products through continued research in the field of science has made us aware that in our own communities there are trained technicians, engineers, scientists, and many other trained people at work in the field of Science. We have only to look around us to find Science principles at work for teaching examples or study problems to have today's teaching with a modern vision.

The people you know, the gas industry that serves you daily, can offer you many study problems in your social and applied science classes by a visit to the Gas Company's meter shop or a field trip to see how a gas well is being drilled. There you will be able to see actual chemistry or physics principles working to make your community and home a healthier and happier place to live.

As you plan a field trip first ask yourself—

What lesson do I want the students to learn? What objective?

Do the classroom assignments cover more than one day of study and research?

Is there an industry in the community that has study principles that will coincide with the classroom lessons?

Also—

Can transportation be easily arranged for the field trip?

Will a whole day be needed for the proposed trip?

REMINDER — KEEP THE SCHEDULE SIMPLE — DO NOT CROWD THE PROGRAM

Then—

Call the manager of your local gas company and arrange a meeting to discuss plans for a field trip.

Discuss—

The trip objectives

The gas company can better serve you if they know what lesson you want to get across to the students.

Type of program available—Listing is only a suggestion.

Plan the trip in sequence as you would a lesson plan for classroom teaching.

—Drilling for Gas	*Optional*
—Compressor Station	
—Underground Storage	Propane Plants
—City Measuring Station	Gasoline Plant
—Meter proving and Repair Shops	(if available in area)
	Land and Lease
—Gas Dispatchers Office	Billing Department
	Chart Room
	Map Department

Three hour over all study trip is most desirable. This need not include travel time.

You may want a discussion leader on the bus to highlight points of interest on last visitation while enroute to next part of program.

Discuss transportation—

May be furnished by school or utility (often the utility will charter a bus for the trip.)

Facilities for eating and rest period must be included in the day's schedule.

Utility usually plans the luncheon at their Home Service Center, at a church or other eating place. This depends upon the schedule and trip location at lunch time.

Age of group and size of group.

Students should be in same class if possible to receive the most from the trip and discussion.

Decide on number to be assigned to each Guide. Have each group numbered and have them stay as a group throughout the day.

Decide on a time of starting and time to return.

Stress the need for promptness throughout the trip.

Science in Action—in the Gas Industry Field Trip

Suggested Program

I. Day before trip, gas company representative will present to the class—

* "The Eternal Flame," a 16 mm., 30 minute movie.

  A full story of Natural Gas from its formation years ago to the present drilling, production, transmission, and utilization.

* There are many other Natural Gas Industry films. Each company has one or may secure one for this part of the program.

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A Young Chemist's Visit to Goethe

• By Ralph E. Oesper, Ph.D.
UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

An accident, a cat, the author of "Faust" and a gift of green coffee all play an interesting role in the life of a young chemist.

You will find both scientific and human interest in this article.

Dr. Oesper, emeritus professor of analytical chemistry, has written many fine articles on the history of chemistry. He has translated two articles by Dr. Paul Walden for THE SCIENCE COUNSELOR *in the March 1955 and September 1955 issues. In addition he is well known for his semi-popular lectures on subjects related to the history of chemistry.*

●

The history of the arts and humanities is filled with instances of "one novel" writers, "one opera" composers, "one drama" playwrights, and parallel instances are not rare in chemistry. On the other hand there are many cases in which an accidental early discovery was the inciting preliminary to a full life of scientific achievement. This latter was true of F. F. Runge (February 8, 1794 — March 27, 1867.)

Friedlieb Ferdinand Runge was the third of seven children born to J. G. Runge and his wife Catherina at Billwärder near Hamburg. Money was scarce in this children-rich parsonage and even the necessities were in short supply. In his autobiographical notes, Runge[1] wrote: "When my young brothers and sisters and I complained about the unpalatability of our scanty fare my mother would say: 'Just wait until tomorrow and you will be glad to see it on the table, no matter how it is cooked.' " The village school had not much to offer, so the father, a well educated man, gave his children supplementary private lessons.

Young Runge had much free time which he spent in the open where he learned to appreciate the beauty and secrets of nature. It was natural for him to hope that his life could be spent in a trade or profession which would bring him into contact with the natural sciences. Pharmacy was indicated and in 1810, after he had finished the lower school, he was apprenticed to his uncle, the manager of a flourishing apothecary in Lübeck. Here he received a thorough training in all the branches of this profession. What he learned, he learned well, particularly those things which pertained to the "chemical craft." To the end of his life he remembered, with discomfort, the large quantities of itching salve that he had to prepare for the populace and the French troops who were then occupying that region.

While still an apprentice, he made the first of his remarkable discoveries, a discovery that was to become exceedingly valuable in ophthalmology. It will be best to tell the story in his own words.

It was a war-torn period, and Napoleon was preparing to invade Russia. All capable of bearing arms were called to the colors, and because of a reluctance to serve under a foreign tyrant, it was becoming increasingly difficult to buy a substitute.

Through the recommendations of my uncle, I had gained entrance into several prominent families, and soon the son of one of these was my bosom friend. One evening he came to me at the apothecary shop. He was greatly perturbed and he told me that he had been ordered to appear for an examination on the day after tomorrow, and that since he had no physical disabilities he probably would have to become a soldier.

"I would rather mutilate my hand than take part in this shameful war," he sighed.

"That is not necessary," I replied, "Trust me, because I believe that I can temporarily incapacitate you to such an extent that they will let you go without further ado."

"What do you propose to do to me?"

"I will make you blind for twenty-four hours."

"How can you do that?"

"Listen. About eight weeks ago, I was filling a prescription and by the physician's order this medicine was to be prepared by dissolving boiled hyoscyamus juice in water. I did this in a mortar and because of carelessness a drop of the solution flew into my eye. I felt no pain and at first noticed no change, until an itching and twinkling drove me to the mirror. I was astounded when I saw the great change that had taken place in the appearance of my eye. The iris had almost disappeared and my eye looked exactly like that of a man afflicted with a black cataract. My vision was greatly diminished, which fact I did not discover until I closed the healthy eye. I do not know why I did not become anxious about this dangerous state of my eye. It lasted for several days. Finally the vision returned, and with it the natural extension of the iris and both pupils were again the same size and everything had reverted to its previous condition. Now look, I will produce a sickness of this kind in both of your eyes, and it will be a miracle if after even the most superficial examination you are not dismissed as unfit to serve."

After a few objections, that were easily overcome, my friend consented to this deception, which at the time was admittedly reprehensible, but probably saved his life; few of those who were dragged to Russia from Lübeck returned (1812).

His temporary blindness lasted about thirty-six hours, it passed away painlessly and left not the slightest ill effect.

As time went on, Runge decided that he would get more schooling no matter what the cost. In 1816, he enrolled at the University of Berlin to study medicine and natural science, and after two years he transferred to the University of Göttingen. He was attracted to Göttingen by the excellent chemical instruction of Stromeyer[2], who had organized laboratory courses there in 1809. How Runge met the inevitable expenses is a mystery. As a research project he chose a study of various poisonous plants, especially those of the nightshade family. The results were encouraging but he was nevertheless not too happy in the university atmosphere which prevailed at Göttingen. Both the students and the faculty adopted a stiff attitude, much was made of social position and birth, and to Runge such formality was against the grain. Accordingly, he transferred after one semester to Jena because the human approach was more evident at this school. Here he came under the influence of the noted chemist Döberereiner[3], the chemical consultant of Goethe.

In Jena, Runge continued his studies of toxic plants and in 1819 received the doctorate in medicine on the basis of his dissertation "De novo methodo veneficium Belladonnae, Daturae nec non Hyoscyami explorandi" (On a new method of detecting a poisoning with belladonna, stramonium and also hyoscyamus.) He found that the basic toxic materials of these three plants exert the same mydriatic action on the eye and that this dilating effect can be used to reveal slight amounts of these poisons, and hence he provided forensic chemistry with a valuable aid. It is only necessary to extract a little of the suspected sample with water and to place a little of the extract in the eye of a cat by means of a brush. The difference in the pupils of the two eyes will soon be visible. In due time, this action was introduced into medical practice and is now widely employed, but how many ophthalmologists are aware that their use of atropin goes back to Runge, the young German pharmacist and chemical student?

Runge's researches with toxic plant materials soon became known among the student body; he was recognized as one "who constantly was rummaging around in plant poisons and who hoped to do something useful in this way," and he was popularly known as Dr. Gift (Poison). Runge demonstrated the action of these extracts on the eye of a cat to Döbereiner, who described this finding "as highly instructive and of the greatest importance." That very evening he told Goethe of the remarkable discovery and the next morning he instructed Runge to present himself at Goethe's residence in near-by Weimar on the following day, October 3, 1819.

In 1866, many years later, Runge wrote:

I do not deny that a very special thrill ran through my young being. Up to then I knew very little about Goethe's accomplishments, but I knew his '"Faust" by heart and this was more than enough to make me appreciate the incalculable worth of this man, who condescended to give an audience to an insignificant student with a cat under his arm.

And it actually happened this way. When that afternoon, in a borrowed frock coat (then a rarity in Jena) and a formal townsman hat (Philister Hut) acquired in the same manner, and a cat under my arm, I strode through the market place, there was a general commotion. The students, who were standing around in groups, suddenly took up the cry: Dr. Gift and I in my odd costume found my way barred. With a seriousness, which I, in my later years, never again attained, I said: "Let me alone, I have an important errand to do, I am going to visit Goethe."

I was permitted to go on my way, and no smart aleck calls were sent after me. I attribute this in part to the general favor I enjoyed as a 'good fellow' and in part to the nickname Dr. Gift. Diligent striving, even though it has humorous aspects, is seldom ridiculed. Therefore Dr. Gift actually was not a derisory title but an honorary appelation for me.

It was fortunate that I did not know that Goethe was Privy State Minister, and though I had been instructed to address him as "Excellency" I had no notion of what was meant by court manners or etiquette. Therefore, as soon as I told the chamberlain my name, I with the greatest self-assurance, entered the reception room, where Goethe appeared in a few minutes.

I do not remember what greetings were exchanged. The fine-looking tall, imposing figure made such a powerful impression on me that I tremblingly handed him the cat as though I wished to defend myself with it. He said: "So here is the future terror of the poisoner. Show me, if you please."

I then turned the cat's head so that the light struck both eyes equally, and with astonishment Goethe noted the difference in the two eyes: in contrast to the narrow slit in one eye, the large round aperature in the other was all the more striking because due to a rather large dose the entire iris had retreated and was invisible.

"How have you achieved this action?" inquired Goethe.

"With henbane, Your Excellency. I have placed the unmixed juice of the crushed plant in the eye, that is the reason the action is so powerful."

He remarked: "Döbereiner told me that the species of the *belladonna* and *datura* act in exactly the same manner as that of *hyoscyamus*, and that you have found that the material which has such a powerful altering effect on the eye occurs in all parts of the plant, from the root to the blossom, fruit, and seeds. How is it with other plants, particularly those which have a related form?"

(Continued on Page 68)

Acetylene in Perspective

• By W. S. Walker, C.E., (University of Wisconsin)
MANAGER-CARBIDE, LINDE AIR PRODUCTS COMPANY, A DIVISION OF UNION CARBIDE AND CARBON CORPORATION

First used for lighting, next for steel fabricating, then for chemical manufacture—acetylene is now being supplied by pipeline for new and expanding applications. Its role in our future will be a vital one.

Teachers of chemistry will find new and useful information in this paper.

Acetylene furnishes light for specialized applications, heat for steel fabricating, and chemicals for myriad uses. It is a product of great importance and, strangely enough, became so through a process discovered quite by accident.

In the year 1892 in Spray, North Carolina, Thomas L. Willson and Major James Turner Morehead were attempting an electric furnace method for making calcium, to be used for the reduction of aluminum ore. In one of their experiments slaked lime and tar were reacted in the furnace. The result was a gray-brown, stone-like product, which, when quenched with water, liberated a pungent smelling gas. The product was calcium carbide and the gas, acetylene. The production method that Willson and Major Morehead stumbled on proved to be economically feasible and is to this day the most important way of making acetylene, despite over 60 years intensive investigations of other routes.

$$CaO + 3C + heat \longrightarrow CaC_2 + CO$$

Lime	Coke	Calcium Carbide	Carbon Monoxide

$$CaC_2 + 2H_2O \longrightarrow HC{\equiv}CH + Ca(OH)_2 + heat$$

Calcium Carbide	Water	Acetylene	Slaked Lime

The potentialities of acetylene for lighting soon led to the formation of commercial companies to produce calcium carbide. Early plants were located in Niagara Falls, New York and Sault Ste. Marie, Michigan near sources of economical hydroelectric power. Predecessors of Union Carbide and Carbon Corporation began operating plants at these locations in 1898.

In the early part of this century acetylene lamps were widely used for barns and homes, for automobiles, and even for streetlights. To this day acetylene lights the way in many special applications—in portable lights for mines and railroad car inspection, also in buoy lights for sea lanes. Small miners' lamps and two pound tins of "Union" brand calcium carbide can still be purchased in hardware stores and mail order houses, and they make excellent teaching aids to demonstrate the generation of acetylene from calcium carbide.

Oxy-acetylene processes soon rivaled the acetylene lamp in commercial importance and, in 1907, resulted in the first large-scale production of oxygen in the U.S.A. (by fractional distillation of air). Burning at a temperature of about 5600 deg. F., the oxy-acetylene torch provides the hottest flame generally employed by man. Oxy-acetylene processes are widely used in metal fabricating and, in recent years, have received a significant boost by the steel industry's use of oxy-acetylene surface-scarfing for removing scale and surface defects from semi-finished steel.

Acetylene is chemically reactive and this quality has led to its increasing use as a raw material for chemical manufacture. Today, about two-thirds of the acetylene produced from calcium carbide is used for chemical synthesis.

.Research on the use of acetylene as a chemical raw material commenced in 1914 and led, in 1925, to the commercial production of acetaldehyde and acetic acid at Niagara Falls.

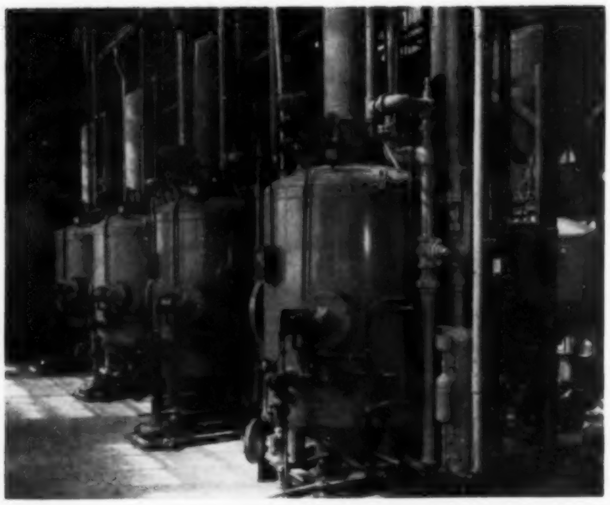
$$HC{\equiv}CH + H_2O \xrightarrow[\text{dil. } H_2SO_4]{HgSO_4 \text{ in}} CH_3CHO \xrightarrow{(O)} CH_3COOH$$

Acetylene	Water	Acetaldehyde	Acetic Acid

Other acetylene-derived chemicals soon followed. Today, acetylene is also an important raw material for vinyl chloride, vinyl acetate, neoprene, trichlorethylene, and acrylonitrile.

Vinyl chloride is the most important acetylene-derived chemical taking about 30 percent of the acetylene

TAPPING MOLTEN CALCIUM CARBIDE into chill cars is a spectacular sight.



FOUR OF A BANK OF SIX modern acetylene generators at one of Linde Air Product Company's plants, for making acetylene from calcium carbide. Acetylene produced at this plant is supplied by pipeline over an area of several miles to chemical customers.

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$$\underset{\text{Acetylene}}{HC{\equiv}CH} + \underset{\text{Hydrogen Chloride}}{HCl} \longrightarrow \underset{\text{Vinyl Chloride}}{\begin{array}{cc} HC & =CH \\ | & | \\ H & Cl \end{array}}$$

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Acrylonitrile is used to make synthetic fibers like "Orlon," "Acrilan," and "Dynel." It is also a raw material for oil-resistant synthetic rubber and for plastics that have improved impact strength. Acrylonitrile can be made from acetlyene and hydrogen cyanide.

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Neoprene is a synthetic rubber resistant to deteriorating effects of weather, heat, and many oils and chemicals. It is used to make electric cable coverings, hose, conveyor belts, industrial truck tires, and shoe soles and heels. Neoprene is made from chloroprene, which, in turn, is derived from vinylacetylene and hydrogen chloride.

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A pioneer organization in the development of many of the uses for acetylene has been Union Carbide and Carbon Corporation and its Divisions—Electro Metallurgical Company (calcium carbide), Linde Air Products Company (acetylene and oxygen) and Carbide and Carbon Chemicals Company (acetaldehyde, acetic acid, vinyl chloride, and vinyl acetate).

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With pipelines to supply it economically and with new techniques for using it, acetylene is just starting to realize its full potential as a chemical raw material. It now stands on a new frontier that offers vast new areas for growth and benefits for everyone. ●

A Case Study in the Logic of Science: Concept of Chemical Element

• By Sister Mary Marguerite Christine, B.V.M., Ph.D., *(St. Louis University)*
DEPARTMENT OF CHEMISTRY, MUNDELEIN COLLEGE, CHICAGO, ILLINOIS

Modern science offers a system of physical theories to explain the physical data of experience without relating them to the problems of philosophy. Formerly science and philosophy were a single discipline.

This study of seventeenth and eighteenth century definitions of the concept element clarifies the changes that have occurred in the methodology of science.

The theory of methodology used in this article was proposed by the philosophy department of St. Louis University.

From the time of Aristotle to Lavoisier, the concept of element was amorphous and undetermined, a hybrid of both scientific and philosophic parentage. Without a clear and sharply defined notion of elements, chemistry was unable to advance but was overburdened with experiments sterile in theory, and observations barren of significance. One hundred years before Lavoisier, Robert Boyle had composed a definition of element which appears sufficiently accurate to be used in chemical work today, yet for a century it lay dormant, unused. When Lavoisier defined his concept of element in very similar terms, the modern science of chemistry was born.

This paper proposes to offer an explanation of the hundred years' lag by a comparison of the theories of knowledge and methodologies used in the formation of the two definitions of element.

The problem is rooted in the sixteenth and seventeenth centuries, popularly associated with the so-called "scientific revolution," from which stems the present dichotomy in scientific and philosophic thought. It has been conceded that, in the main, the struggle in those centuries was a conflict in methodology between the scholastic philosophers and the new scientists. Until this period, men used the same intellectualistic or philosophic method in their scientific studies as they had used in pursuing ontological problems. Philosophy dominated the inception, the method of development, and the final achievement of all branches of knowledge.

The problem of the nature of science as a kind of knowledge and its relation to other disciplines is more sharply focused in these days of the twentieth century than it was at its very inception in the intellectual revolution of the 1600's. The clarification of the relation between philosophy and positive or scientific knowledge has become a task of major importance for those who recognize the essential value of the unique aspects of reality acquired in each discipline.

Science would assume the role of the "philosophy" of the age. Here lies the modern conflict. To resolve it is not a mere academic attempt to sharpen the boundary lines and to curtail foraging in forbidden fields. The problem is more crucial. Science would give us answers to all our questions in every aspect of human living. To counteract the obscure thinking and the vacuous writing of modern "intellectuals" to whom science is the modern philosophy, it must be demonstrated that explanations of a non-scientific type are necessary and true, that the kind of knowledge obtained from philosophy cannot be legitimately obtained from natural science, and that the questions bordering on ultimates are of a strictly philosophical or theological nature. In such a solution lies the restoration of the correct order in the hierarchy of disciplines.

A way of resolving the conflict, employed by many current thinkers, is to view it as a problem in the nature of knowledge. Since knowledge is specified by its formal object, different types of concepts may be distinguished, depending on the proper object of the knowing act. Two types of concepts may be differentiated: the ontological and the constructural, by means of which the proper knowledge of philosophy and science, respectively, are obtained.

An ontological (or philosophical concept) is one which corresponds directly to something in the object. This correspondence is not a direct point-for-point likeness of the object in reality, but rather a representation, a mental word, a formal sign. The pure ontological concept is the means by which the direct intelligibility of some reality is expressed. The concept need not necessarily be total and complete; many times it is partial or inadequate, but, nevertheless, it is always a direct understanding. There is no adjustment necessary to relate it to reality.

Concepts that are peculiar to scientific knowledge are termed constructural because they are not discovered directly in reality but always involve some method or process of "construction." This demands that scientific knowledge have a phase intermediate between the direct contact with reality (which may be called experimental) and the distinctive procedure used in formulating the concept. The intermediate phase has been called the experimental phase, the selective or abstractive mediate contact with reality.

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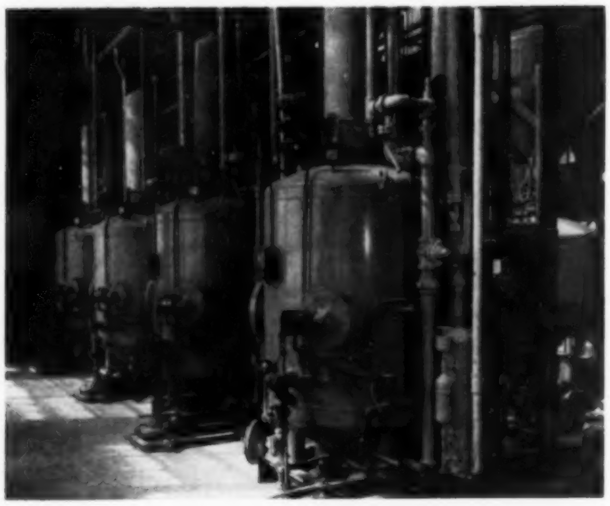

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complex resultant of conventional and physical facts drawn from experience. There is only a functional relationship between the mental construct and the primary factors from which it originated. It is truly an understanding, but only an indirect understanding or an indirect control for thinking or for manipulation of a reality.

When both types of concepts are understood, the ontological and the constructural, and their limitations appreciated, they can exist together. Today the major scientific fallacy lies in moving directly from constructural concepts to the ontological reality, as the scientist proceeds to encroach on philosophic territory.

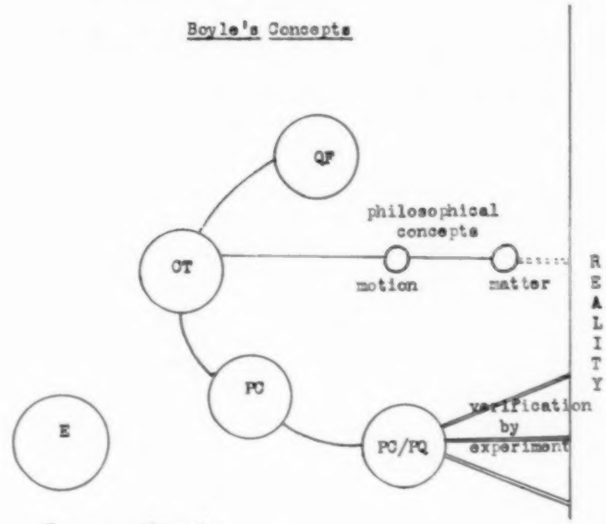
In a theory originated by M. Maritain and elaborated at St. Louis University, two distinctive methods in formulating concepts, specifying philosophical and scientific knowledge, are postulated. The ontological concept is elaborated by using that power possessed by intelligent agents, of understanding presented reality directly. It originates through the method of intellectual insight, deepened by reflection, or through argumentation based on intellectual insight. In a true realism, reflective consciousness discovers knowledge of things, and finds itself in immediate contact with reality. This knowing, however, must be studied by reflective contemplation. The philosophic method, therefore, is a composite of contemplative insight and induction through insight.

The constructural method applies to the formation of all so-called scientific concepts, exclusive of those proper to mathematics. The product of the constructural method is commonly called the "construct," since there is always involved a fabrication, a putting together of constituent parts, an operation or a construction of some sort. The method of insight, invaluable in the formation of philosophical concepts, is incapable of producing the constructs which make for progress in scientific knowledge. However, the presuppositions of science, upon which is built the superedifice of scientific theory, are philosophical and metaphysical, concepts that were originally gained through insight, but are now so completely accepted and absorbed that they are assumed unwittingly.

Concepts that are typical of the constructural method can never be predicted directly of the real things in experience. There is an analogous correspondence between features in the construct and those in reality, but no direct identification.

When working with constructs, the importance of the method or operation must be emphasized. It alone gives meaning to the concept. A valid construct is not purely factitious nor arbitrary; it is not a product of the intellectual imagination, for it bears a determined relation to experience and to ontological reality. The constructural method is characteristic of science as such. The method is one of "rational induction," a term used to indicate a roundabout and complicated process of discovery, in contradistinction to the immediate understanding obtained by an intelligible induction which discovers essences.

FIGURE I



E - element
QF - quality formation
CT - corpuscular theory
PC - primary concretion
PC/PQ - primary concretion with permanent qualities
single line - logical connection between concepts
double line - direct connection to reality
dotted double line - faulty connection to reality

The constructural method is not a single method. Types of constructs vary. They can originate through operational, functional, imaginative or relational construction, commonly demonstrated in the operational definition, the metaphor (including the physical model or picture), the schematic correlation of merely observed data, and the combination of pure beings of reason with observed or interpreted data.

By applying this analysis of methodology to the concepts of chemical element as formulated by Boyle and by Lavoisier, a reason for the apparent lag in chemistry becomes clear. The evaluation of their respective concepts is accomplished by synthesizing the final concept from its roots, testing each link of the chain from reality to the constructed product.

As one reads Boyle's definition:

> . . . I now mean by Elements, as those Chymists that speak plainest do by their Principles, certain Primitive and Simple, or perfectly unmingled bodies; which not being made of any other bodies, or of one another, are the Ingredients of which all those called perfectly mixt bodies are immediately compounded, and into which they are ultimately resolved.[1]

it becomes apparent that though he had disdained and demolished the theory that earth, air, fire and water were elemental, he actually retained a concept of element identical with that of Aristotle and Paracelsus. For them and for him elements were simple, primitive, and totally unmingled bodies. Such a notion was purely philosophical for it was based not on experimental facts, but upon what was thought to be a philosophical inspection of reality.

[1] Robert Boyle, *The Sceptical Chymist* (New York: Everyman's Library, E. P. Dutton and Sons, 1901) p. 187.

The latter part of the definition is purely operational and as such constitutes a valid construct. The fact that it was completely static having no influence on the progress of chemistry indicates that his operational construct was vitiated by the former philosophical aspect of the definition.

Upon examination of Boyle's philosophy of nature, it is clear that his concept of element (simple, primitive body) is decidedly at variance with his own notions of simple particles. Herein lies the essential weakness of the concept. His natural philosophy was built on a corpuscular theory which, in turn, was based on his Cartesian idea of matter. Using a diagram adapted from Margenau[2], the relationship among his corpuscular concepts or constructs can be readily seen.

Matter was pure extension, divisible and impenetrable, an actual substance. Boyle attained this concept of universal matter by a philosophical method, by what he considered a direct insight into the reality of things. The induction was partial and faulty; consequently, it was an invalid and inadequate basis for the entire structure of his natural philosophy. Using his philosophical notions of matter and motion, Boyle built his construct of corpuscles (CT). Matter was divided into small fragments by means of motion. These minute particles or corpuscles were homogeneous and possessed size and shape; they were distinguished merely by their order and situation in relation to each other. As the corpuscles arranged themselves in nature, the qualities of new substances were observed (QF). Thus, for Boyle, there could be no inherent distinctive characteristics which could identify an element.

Enduring and permanent elements could find no place in such theory. Either there would be an infinity of elements, if they were to be identified with simple bodies like his corpuscles, or there was none. Boyle was hard-pressed to choose one of the alternatives but, to the end of his life, his elementary theory remained ambiguous. Unknowingly, as he applied the philosophic method of induction-through-insight to form his concept of elements (simple, primitive and indestructible) he was hindered from using the valid operational technique expressed in his definition.

There was an added feature in his corpuscular theory which would have satisfactorily permitted the reality of elements as understood today. This feature was the concept of primary concretions with permanent qualities (PC/PQ). (A concretion was a union of two or more corpuscles.) Since it was obvious to Boyle that there were some substances that maintained a certain permanency and identity through many and varied experiments, e.g., gold and mercury, he accounted for them by attributing to their respective arrangements of corpuscles a permanent and unchanging formation. Thus the qualities of these substances would be enduring. Here was the concept of element as it is understood today. Yet, Boyle, blocked by his philosophic notions, could not make the transition to this perfectly valid construct in his theory. His concept of element (E) remained an insular concept related neither to his corpuscular theory nor to reality. Consequently, it remained completely fruitless in the field of chemistry.

To be valid, a scientific concept must have logical connections (single lines in Figure I) to other concepts, and be capable of experimental verification in nature (double lines in Figure I). Boyle's element lacks these major requirements because it was never sharply delineated by Boyle and therefore could not be used in any logical connections, and was totally unproductive in theory since no experiments nor auxiliary constructs as hypotheses originated from it. In contrast, it is noted that his concept of primary concretions with permanent qualities (PC/PQ) has logical and experimental connections, both in construction and in verification.

Boyle's definition thwarted a requirement of simplicity, since it was a complex construction of both philosophic and scientific constituents. Its total disqualification as a valid construct can be summarily attributed to its lack of internal consistency. The conflict between the accepted notions of elements and the corpuscular philosophy expressed itself in his definition

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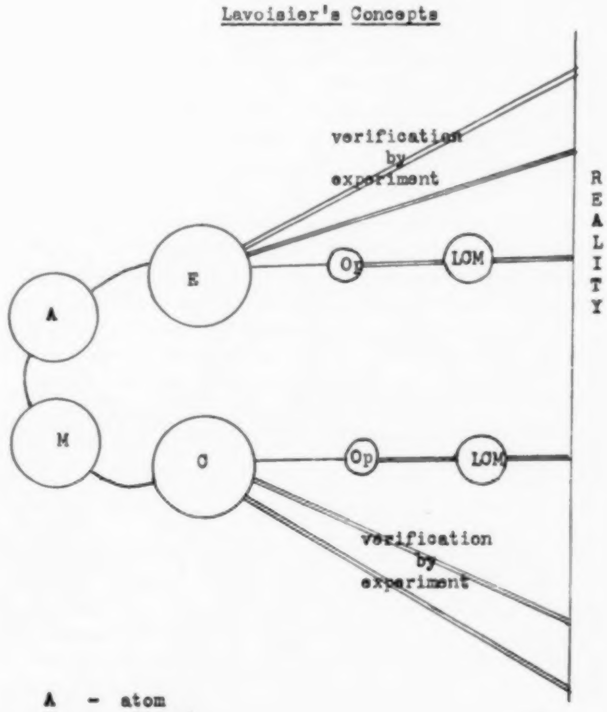
FIGURE II

Lavoisier's Concepts



A - atom
E - element
M - molecule
C - compound
Op - operation
LOM - Law of Conservation of Mass
single line - logical connection between theories or concepts
double line - direct connection to reality

[2] Henry Margenau, *The Nature of Physical Reality* (New York: McGraw-Hill Book Company, 1950) p. 85.

P. D. S. M. T. A.

• **By Sister Mary Alexis Anna, S.C., M.A.,** *(Duquesne University)*
ELIZABETH SETON HIGH SCHOOL, PITTSBURGH

P.D.S.M.T.A. are the initials of the "Pittsburgh Diocesan Science and Mathematics Teachers Association." These teachers have, by cooperative effort, accomplished much to improve the quality of science teaching in the Pittsburgh Diocesan schools.

This group of religious and lay teachers have found that in union there is not only strength but self-improvement and enjoyment.

The organization carrying the proudly significant title, "The Pittsburgh Diocesan Science and Mathematics Teachers Association," had its beginnings many years ago. Doctor H. C. Muldoon, Dean of the School of Pharmacy of Duquesne University, had long seen the need of a science teachers' get-together project and the good that would result from such an undertaking. He saw it as a venture that would create initiative and guide and encourage the young scientist of the future. Impelled by this conviction, Dean Muldoon convened the first "Science Conference" at Duquesne University, in 1932. The seed was sown and the work began.

In the early thirties the conferences drew renowned speakers from many parts of the United States. The lectures delivered by those able professors were invaluable, particularly for reference work. Many of these lectures have been preserved in the pages of the *Science Counselor*.

In the beginning, Biology was the only science considered, a workshop under the tutelage of Mr. James Kosinski was founded at the Carnegie Museum. He conducted classes on Saturday morning. In these classes lectures were given, experiments conducted, and models and casts of starfish, worms and the like were molded from wax, latex or plastics and then painted with oils. Regular meetings were conducted throughout the year and a small fee, collected from each member, was found necessary to meet expenses.

Modern Beginnings

During the year 1942-43, a group of teachers, working conjointly with the then Reverend Thomas Quigley, Superintendent of Catholic Schools of the Diocese of Pittsburgh, began a preliminary study for organizing an association of teachers. The leaders of this movement were: Sr. Rosaire, I.H.M., Chairman of the Department of Science; Sr. Macrina, I.H.M., Chairman of the Department of Mathematics; Brother Joseph Kuntz, S.M.; Brother Gregory Nazianzen, F.S.C.; Sr. Mary Alexine, S.C.; Sister M. Placedes, C.D.P.; also Brothers Joseph Pansar and Robert Schuelein, S.M. These may be said to have formed the nucleus of the organization.

To regulate the rapidly growing institution, the need of a constitution was apparent. Sister Rosaire presented a rough sketch of a constitution based on one used in the diocese of Chicago. Shortly after, Sister was sent to Catholic University, Washington, D. C. and the presidency was delegated to Brother Joseph Kuntz, S.M. who, with assistance of Rev. Thomas Quigley, continued to further the interests of the organization.

In 1945, the first constitution was drafted, and it was adopted in 1946. Now, the association was a-going concern.

"The Pennsylvania Junior Academy of Science," previously known as the "Junior Academy of Science" was organized in 1946. Sister Gabriella was appointed its first chairman and continues to hold this office. In 1951, Sister requested the board of directors of the

(Continued on Page 74)

THE EMBLEM of the association, was designed by Brother Joseph Kuntz. On it are inscribed red and blue fields of patriotic origin, symbolizing also the colors of Duquesne University under whose patronage the association has matured, the gold and green were taken from the coat of arms of the Most Rev. Hugh C. Boyle, during whose time the P.D.S.M.T.A. was established; the Bishop's Pectoral Cross and Crozier is emblamatic of its leadership and union with his Excellency, the Most Rev. John Francis Dearden. Superimposed over the dextral field in the shield is an osciliograph tube, sound waves and bolt of lightning indicating Physics while the retort and flask signify Chemistry. Sinistrally located over the fields are the slide rule and compass reminding one of Mathematics, and the microscope in the lower Quadrant represents Biology.

Facts and Fancies About Food Fats

• By Robert S. Harris, Ph.D.

PROFESSOR OF NUTRITIONAL BIOCHEMISTRY AND DIRECTOR OF THE NUTRITIONAL BIOCHEMISTRY LABORATORIES, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Popular prejudice and half-facts have obscured the importance of food fats in nutrition. This fact-filled article conclusively proves that fats are essential constituents of a nutritionally sound diet.

This paper is a digest of a talk by Doctor Harris, delivered on June 23, 1955, at White Sulphur Springs, West Virginia, before a conference sponsored by the National Association of Margarine Manufacturers.

A few years ago, two hundred "food fallacies" were reported by a committee of the American Dietetic Association. These false notions about food persist all over the country. Among them: fish is a "brain" food; milk doesn't go with lobster; cheese is "hard" to digest; people who do heavy work need more meat; fatty food should be avoided in hot weather.

Of all the strange ideas listed above, it's not too surprising to find misconceptions about fat and fatty foods. Fat is, after all, a sort of stepchild. When it is not neglected altogether, it is abused. People just don't seem to understand the important role of fat in nutrition. Other nutrients—vitamins, minerals and proteins—have caught the public fancy and more research has been done in those areas. As a result, public understanding of fat and its importance in nutrition has developed slowly.

But a fuller knowledge of the vital role of fat is beginning to reach the public. Today, people are beginning to recognize fats for what they are—essentials to our good health and nutrition.

Here are some of the most commonly believed fallacies concerning food fats:

Fallacy No. 1: "Fats are indigestible."

Fact: Repeated studies show that 92 to 98 per cent of all food fats and oils are completely digested. The digestibilities of some common food fats (or "oils") are:

butter	97%	vegetable shortening (cottonseed oil)	98%
margarine	97%	olive oil	98%
chicken fat	97%		
lard	97%		

All the usual food fats are highly digestible—whether they come from plant or animal sources. This is also true whether or not they are hydrogenated (i.e., changed from liquid into solid by adding hydrogen in limited quantities) as long as they will melt below 50° C (122° F.) From the standpoint of digestibility, there is little to choose today between animal fats, vegetable fats, butter, margarine, and hydrogenated shortening.

Fallacy No. 2: "Margarine is harder to digest than butter."

Fact: A considerable body of research shows both products have equal digestibility. Properly processed fresh butter and properly processed margarine are no different in this respect.

Fallacy No. 3: "Fatty foods are unusually fattening."

Fact: A calorie of fat has the same energy value (and therefore is equally as fattening) as a calorie of starch, a calorie of sugar, or a calorie of protein. Or, as Gertrude Stein might have expressed it: "A calorie is a calorie is a calorie."

It's true, of course, that a pound of butter or margarine or lard contains more calories than a pound of starch or sugar. But people eat less when they eat calorie-rich foods. Studies of both human beings and laboratory animals show that well-balanced diets of different calorie composition promote the same gain in weight per calorie consumed. It is not true, therefore, that fatty foods are more fattening. Moreover, there is no nutritional reason for omitting fats and fatty foods from reducing diets.

Fallacy No. 4: "All body fat comes from food fat."

Fact: It's natural to assume that body fat is food fat "put in storage." However, studies indicate that when a fat is metabolized (i.e., digested and disintegrated), it is broken down into two-carbon compounds. These enter the "metabolic pool" from which new compounds in the body are manufactured. Some of these fragments are burned as "fuel," some are used to construct body tissues, and some are resynthesized into new fat and laid-down in tissues.

The fact that the fatty acid composition of human fat is different from that of any food fat is sufficient proof that human fat is not simply "stored" food fat.

Still further proof is provided by experiments in which carbohydrate and protein in various forms were "labelled" with radioactive isotopes, fed to animals, and proved to be changed to body fat. It now seems clear that the fat in our bodies comes from *all* the food we eat and only partially from margarine, butter, and other fat in our diet.

Fallacy No. 5: "Fats cause atherosclerosis."

Fact: Atherosclerosis (a degenerative disease of the arteries) is believed to be caused by many things: diet, a person's tendency to produce and store too much of a substance called "cholesterol," etc. While the fat content of the diet is possibly a factor in this relationship, there is evidence that other dietary factors are involved. For example, it is possible that the high incidence of atherosclerosis among populations living on high-fat diets is associated with deficiencies of such vitamins as pyridoxine, ascorbic acid, or choline, and is not related directly to fat in the diet.

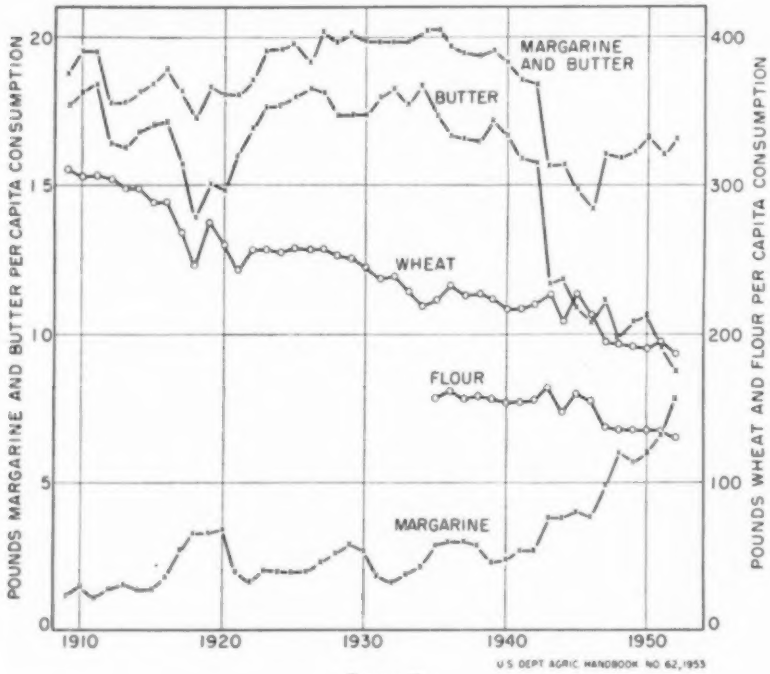


FIGURE 1

It may be suggested, therefore, that the amount of fat in the diet is not the only factor, nor the most important factor involved. The evidence indicates that neither the amount nor type of fat in the diet is *directly* responsible for atherosclerosis. Instead, it seems to be caused by a failure in cholesterol metabolism. This does not mean, of course, that it would be wise to eat excessive amounts of fat.

Fallacy No. 6: "Oxidized fats and fried fats are toxic."

Fact: Heated and fried fats are not toxic under ordinary conditions of use. It is true that rancid fats and oils, when mixed in foods, may destroy fat-soluble vitamins (i.e., vitamins A, E, and carotene) as well as water-soluble vitamins and amino acids. However, when these vitamins were fed to animals separately from their diets, to prevent interaction with fat, the animals grew as well (per calorie eaten) as animals that received untreated fat in their diets.

Fallacy No. 7: "Hydrogenated oils are inferior."

Fact: When oils are hydrogenated (i.e., changed from liquid into solid by adding hydrogen in limited quantities), some of the essential fatty acids become saturated and are destroyed. However, this loss is not important, because the essential fatty acid content of hydrogenated vegetable oils still is higher than that of lard, tallow, butter, and other food fats.

Fallacy No. 8: "Margarine is nutritionally inferior to butter."

Fact: Years ago, when margarine was made from vegetable oils and was not enriched with Vitamin A, this statement was true. Today, it is not.

The standard of identity for margarine requires that it contain a minimum of 80 per cent fat and 15,000 USP units of Vitamin A per pound. Vitamin D is permitted as an optional ingredient. Margarine is naturally rich in tocopherols and essential fatty acids. Pound for pound, butter and margarine are approximately equal in nutritional value.

Fallacy No. 9: "Fats and fatty foods should be avoided in hot weather.

Fact: It is commonly believed that carbohydrate foods, especially salads, should be eaten in warm weather to the exclusion of fats and fatty foods.

During the digestion and metabolism of foods, a significant amount of energy (called the "specific dynamic action") is given off in the form of heat. In mixed diets, carbohydrate is actually the major heat-producing factor, while lard and other fats are major factors in conferring "economy of utilization." Therefore, a person will be hotter on a high carbohydrate diet than he would on a diet of equal calorie content that is rich in fat.

Nutritional Role of Fats and Oils

Fats are important in the diet because they : (1) are high in "fuel" value; (2) give palatability to food; (3) increase the satiety of food; (4) supply essential fatty acids; (5) help absorb fat-soluble factors and act as their carriers; (6) spare thiamine, niacin, pantothenic

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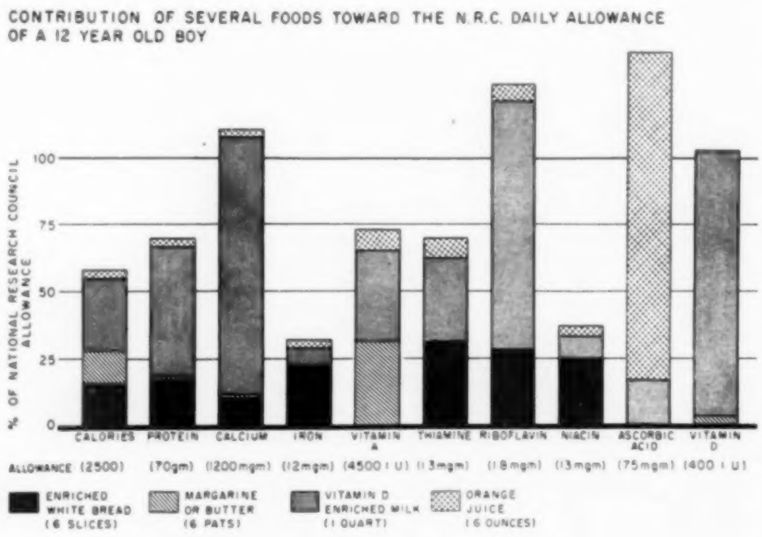


FIGURE 2

Fundamental Aspects of Chelation

• **By Albert E. Frost, Ph.D.,** *(Clark University)*
THE DOW CHEMICAL COMPANY, FRAMINGHAM, MASS.

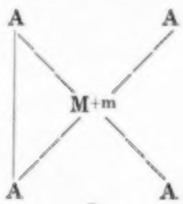
The purpose of this paper is to present in a simplified manner the essentials for an introductory course of that class of co-ordinating agents known as chelating agents and their application to everyday industrial and laboratory problems. This discussion is directed primarily toward those who are interested in gaining a knowledge of this important new "tool" of science and technology. It is suggested as the basis for a lecture period or seminar in analytical or inorganic chemistry because of its close relation to these fields and because the theory and applications of chelation are neglected in most textbooks.

The existence of chelating agents has been known for many years, but it is only recently that significant advances have been made in the chemistry of such materials. The importance of co-ordination compounds in life processes is well known. The various fields of science have realized the significance of the many advances and, as a result, both science and industry are becoming increasingly cognizant of their many and varied applications.

In view of the great activity in the field of co-ordination compounds, a survey of the several factors affecting complex formation especially those factors affecting chelate formation, are given below.

General Concepts

When a metal combines with an electron donor, a complex or co-ordination compound is formed. In the simplest cases, the electron donor, called the ligand, which combines with the metal ion contains only one donor group. When the ligand contains two or more donor groups tied together in some way the resulting complex is called a "chelate." Figure 1 schematically represents the structural element for both these terms.



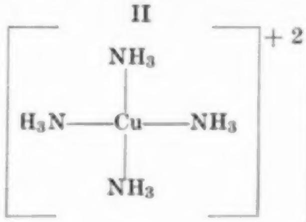
I

The left portion of the figure represents a chelate which may be defined as a complex in which the metal ion is bound in a cyclic or ring structure by a chelating agent or ligand. The right side of the figure represents a complex in which the ligands or complexing groups are present as individual entities not bound together.

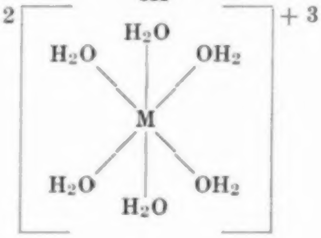
The term ligand denotes an atom, radical or molecule which generally donates electrons to a metal atom to form a more or less homopolar bond.

Common examples of complexes (II-III) and chelates (IV-V) are given below:

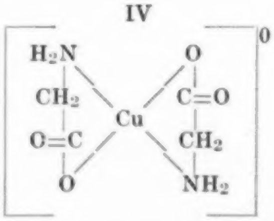
II



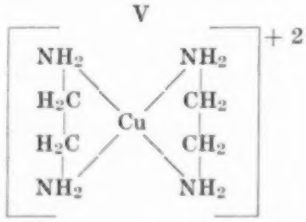
III



IV



V



An important point, often overlooked, is the fact that in aqueous solution metal ions are surrounded by water molecules (somewhat as in formula III) in which the metal to oxygen bond varies from essentially covalent to essentially ionic character with increasing basicity of the central metal atom. Complex formation (and chelate formation) in aqueous solution involves a displacement of the aquated water molecules by the complexing agent with an alteration in the properties of the complexed metal.

When chelating agents possess two, three or four donor groups they are said to be bidentate, tridentate, tetradentate and so on. A metal of co-ordination number 4, such as copper, requires two bidentate donors or one tetradentate donor. Complexes involving unidentate groups cannot, of course, involve chelation since ring formation is not possible.

Chelate compounds are a special class of complex compounds and it might be pointed out that all chelating agents are complexing agents but that the converse is not true. Those complexing agents which form water soluble complexes are known as "Sequestering Agents." This term includes both the simple complexing agents and chelating agents. The term sequestration includes the formation of water soluble complexes in solution as well as the solubilization of slightly soluble metal salts in water. Since the same equilibrium is reached for the same components, the two processes are identical.

Metal chelates may be cationic, anionic or neutral in character depending on the charge of the hetero atoms. In the case of ethylenediamine (V) the hetero atoms are neutral and satisfy only co-ordinate valences producing a positively charged chelate. On the other hand, oxalic acid contains two negatively charged oxygen atoms and forms anionic chelates. The chelating group may also contain one neutral and one ionic hetero atom as in glycine (IV) and satisfy both co-ordinate and polar valences. Chelating agents containing this latter structure in which there is an exact matching of the co-ordination number and charge of the metal by the chelating agent to produce a neutral chelate are termed "Inner Complex Salts." The term *Inner* indicates ring formation, the term *Complex* indicates the presence of co-ordinate bonds and *Salt* indicates salt formation between the metal and the acid group.

Complex and chelate formation is essentially a neutralization reaction and is analogous to the titration of an acid with a base. As such, it fits well into the Lewis electronic theory of acids and bases. According to the Lewis theory, the neutralization of an acid with a base involves the combination of an acid or electron acceptor with a base or electron donor with the formation of a co-ordinate bond. The chelating agent, the electron donor, acts as a base and the metal ion, the electron acceptor, acts as an acid. The net result is neutralization of the metal, or acid, by the chelating agent, or base, with formation of a co-ordinate or homopolar bond. This acid base relationship between metal and ligand is an important point to remember since it explains the great dependence of complexes and chelates upon pH.

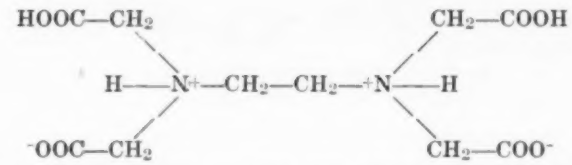
The essential and characteristic feature found in all chelating agents is the ability to form a ring with a metal atom. To do this, the following conditions are essential:—

1. The Molecule or radical must contain two or more groups which can combine with the metal atom with formation of at least one homopolar or co-ordinate covalent bond.
2. Groups or atoms must be present which can co-ordinate with the central metal atom through their lone electron pair (oxygen, nitrogen, hydroxyl, amino).
3. These donors groups must be separated from each other by chains of suitable length to permit the formation of five- or six- membered rings.

These conditions are fulfilled by the alpha- and beta-amino and hydroxy acids and the beta- diketones which form 5- and 6- membered chelate rings respectively with metal ions.

The most important and best known sequestering agents are the condensed polyphosphates, polyhydroxy-carboxylic acids and the aminopolycarboxylic acids. The polyaminopolycarboxylic acids, especially ethylenediaminetetraacetic acid, will be given primary consideration because of the limitations of space, their commercial importance and greater stability to hydrolysis over the polyphosphates.

EDTA, as it will be referred to for convenience, is represented as a di-dipolar ion.



Two of its four protons are associated with the strongly acid carboxyl groups and two with the basic nitrogen atoms. It may act as a sexadentate chelating agent with a metal of co-ordination number 6 or as a tetradentate agent with a metal of co-ordination number 4. It combines with polyvalent metal ions in a 1:1 molar ratio to form stable, water soluble chelates in which the metal ions lose their characteristic chemical behavior even in the presence of common precipitating agents.

EDTA is not a specific reagent but chelates most polyvalent metal ions probably because of the presence of both nitrogen and oxygen donors in the molecule. This non-specificity, however, accounts for its versatility and wide range of applications and explains its position as the leading organic sequestrant.

Measurement and Significance of Stability Constants

A thorough discussion of the determination of metal chelate stability constants is outside the scope of the present discussion. However, it will be of value to mention the various methods applicable to the determination of chelate stability constants. For a thorough discussion of this subject, the reader is referred to the work of Bjerrum, Schwarzenbach and co-workers and Martell and Calvin[1-5].

The reaction of a metal ion with a chelating agent is given by the equation:—

9. $M + xKe \rightleftharpoons MKe_x$

10. $K_c = \dfrac{(MKe_x)}{(M)\quad(Ke)^x} \qquad K = K_c \dfrac{\gamma MKe_x}{\gamma M\ \gamma Ke^x}$

The equilibrium constant K can be calculated by the use of any combination of measurements which permit calculation of activities of the interacting substances. From a knowledge of the formula of the chelate and the total amount of interacting substances (calculated from the quantities added), the value of K can be determined by a single measurement related to the concentration.

The most widely used method is the potentiometric measurement of hydrogen-ion concentration and generally involves a titration technique. From a knowledge of (1) the total concentration of ligand, (2) the total concentration of metal ion, (3) the apparent acid dissociation constants of the chelating agent at the ionic strength used in the titration, (4) the amount of standard alkali used in the titration, (5) the hydrogen ion concentration of the solution; an apparent stability constant can be calculated.

Because of deviations from ideal behavior the technique consists in "swamping" the chelating agent with simple ions to give a solution of known ionic strength

in which the ionic strength is high relative to that of metal and ligand concentrations. The activity coefficient is thus maintained constant and apparent dissociation constants (K_c) may be calculated.

The apparent stability constant can be converted to the thermodynamic formation constant K by determining the apparent stability constant for several ionic strengths and extrapolating to infinite dilution at which point $K_c = K$, or by calculation of activity coefficients from the Debye-Huckel relationship. From the formation constant at two temperatures, the thermodynamic functions of free energy, enthalpy and entropy changes can be calculated. From such data the nature of the metal ligand bond, solvent interactions and correlation of ligand basicity with metal ion properties (electronegativity, ionization potential, atomic number) can be obtained[5-7].

The fundamental relationships involved are:

9. $\triangle F^\circ = -RT\ln K$

10. $$\frac{d \ln K}{dT} = \frac{\triangle H^\circ}{RT^2}$$

11. $\triangle F^\circ = \triangle H^\circ - T\triangle S^\circ$

For metals which form extremely stable chelates ($\log K > 12$) other methods must be used because of the difficulty of accurately measuring the hydrogen ion concentration in the low pH range[4].

Other techniques used to determine stability constants are (1) the polarographic[8-10], (2) spectrophotometric[11,12], (3) radioactive isotope exchange[13,14], (4) measurement of oxidation-reduction potentials[5,15], conductance measurements[16].

Effect of the Ligand

The stability of chelates varies within wide limits depending upon the groups co-ordinated to a given metal ion. In general, the stability of chelates is much greater than the stability of complexes. This increase in stability is largely due to the presence of the ring system about the central metal ion and, the greater the number of rings about the central ion, the greater is the stability of the chelate.

Factors influencing the stability of chelates are listed below. These factors will not be discussed here since they have received excellent treatment by Martell and Calvin[5].

1. Structure of the Ligand
   a. Ring size—5 and 6 membered rings are most stable.
   b. Number of rings—the greater the number of rings the greater the stability.
   c. Ligand basicity—the more available the electron pair of the donor (the greater the basicity) the stronger the homopolar bond formed with a metal.
   d. Resonance—affects basicity of the donor atoms; electrophilic groups decrease basicity whereas nucleophilic groups increase basicity.
   e. Steric effects.
   f. Entropy effects.
   g. Nature of the donor atom.
2. Effect of metal ion
   a. Basicity of metal
   b. Charge and radius
   c. Available orbitals — relative tendencies to form homopolar bonds with electron donors.

Although stability constant data is of great value in the study of chelate compounds, it has definite limitations which must be realized. The limitations arise from the fact that the constants are determined for a given set of conditions and, hence, are strictly valid only under such conditions. The presence of competing anions or increased electrolyte concentration will cause serious deviation from the expected behavior.

From the stability constant data, for example, one would expect that Fe^{+++} ($\log K = 25.1$) would be more strongly chelated by EDTA in alkaline solution than Ni^{++} ($\log K = 18.4$). However, in alkaline solutions, the ferric chelate undergoes extensive hydrolysis with precipitation of ferric hydroxide while the nickel remains chelated.

The common donor atoms and those normally found in chelates are oxygen, nitrogen, and sulphur atoms. The most important single effect on chelation resulting from a change in the donor atom of a chelating agent is the change in basic strength. Oxygen and nitrogen can be considered quite similar in their affinities for metal ions in that both form very strong chelates or complexes with a wide variety of metals. In addition, the tendency for co-ordination diminishes for both elements with increasing substitution.

Although sulphur and oxygen bear a close resemblance to each other in many ways, the relative tendencies for chelate or complex formation are not the same. Examination of many chelates indicates that the effect of substitution on sulphur is opposite to that observed for nitrogen and oxygen. The greater the substitution of the sulphur atom, the greater the donor power of the sulphur atom.

Applications

The applications of chelating agents and chelates are many and cover a wide range of activities. In the majority of applications chelating agents function by virtue of their ability to inactivate metal ions with formation of compounds having properties widely different from those of the free metal ion. Chelating agents which form water insoluble chelates are primarily of interest for solvent extractions and analytical applications. The water soluble chelating agents, sequestering agents, are of greatest interest because of their usefulness as "tools" in science and industry. In most cases, effective removal of the metal requires that the stability constant of the metal chelate be large; that is, that the pM value of the meal chelate be small.

Several of the uses of chelating agents are listed below:—

1. Analytical applications
   a. As primary standard in the determination of various metals[17-20]
   b. Hard water analysis[21]

(Continued on Page 72)

The Challenge of ACRYLONITRILE

• By William E. Wiese, B.S., Ch.E., *(University of Wisconsin)*
TECHNICAL SERVICE MANAGER, RAW MATERIALS, PLASTICS DIVISION, MONSANTO CHEMICAL COMPANY, SPRINGFIELD, MASSACHUSETTS

Acrylonitrile, an extremely reactive chemical, offers innumerable possibilities, as an intermediate, in the production of new synthetic materials. Already it is being used in the production of synthetic rubbers and fabrics.

Conservation-wise acrylonitrile is of considerable interest. It can be prepared from raw materials that are available in almost inexhaustible quantities.

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Speaking aesthetically, as chemists seldom do about chemicals, acrylonitrile (or vinyl cyanide) is an uninteresting, colorless liquid with a faintly pungent odor. Sized up in terms of a myriad of current and potential applications, however, this same chemical becomes a fascinating subject for discussion.

Originally synthesized and identified in 1893, acrylonitrile remained little more than a scientific curiosity for almost half a century. But during the past two decades it has developed gradually into one of the chemical industry's important raw materials.

Currently there are four major producers: American Cyanamid Company, B. F. Goodrich Company, Monsanto Chemical Company and Union Carbide & Carbon Corporation. Combined capacity of these four suppliers has been estimated at about 200 million pounds annually.

Laboratory quantities of acrylonitrile may be synthesized by several methods. But all of today's commercial product is derived from two basic processes. One involves the decomposition of ethylene cyanohydrin into acrylonitrile and water. The second is based on the reaction of acetylene with hydrogen cyanide.

In the first process, decomposition of the raw material (ethylene cyanohydrin) is effected by a dehydrating agent such as phosphoric anhydride in the presence of an appropriate catalyst. Pure product is then collected by means of azeotropic distillation.

The second process, which Monsanto uses at its Texas City (Texas) plant, is more common. At the Monsanto plant the process begins when a mixture of oxygen (from air) and natural gas is burned in a reactor. Water is present to control the reaction. Acetylene and waste gases thereby produced pass through an absorber from which the waste gases are piped away as fuel.

Acetylene-saturated solvent is drawn off the bottom and pumped into a stripper unit in which pure acetylene is boiled off and led to a second reactor. There it is reacted with hydrogen cyanide, which Monsanto produces in a separate operation by reacting air, ammonia and natural gas.

The reactants (acetylene and hydrogen cyanide) are bubbled through a liquid catalyst to produce acrylonitrile. Then the mixture goes to a second absorber where a solvent is added and excess acetylene is purified and reclaimed.

Finally, in another stripper unit acrylonitrile is collected and purified. The product then is pumped into storage tanks, from which it is shipped to Monsanto customers by chemical tank car.

Its high degree of reactivity makes acrylonitrile about as versatile as a chemical can be. Consider its formula: $CH_2{=}CHCN$. Both the double bond and the nitrile group are highly susceptible to reaction with a wide variety of other chemicals.

These reactions are of three general types. *Olefinic* reactions are characterized by a splitting of the double bond. *Nitrile* reactions are based on the reactivity of the nitrile group. *Cyanoethylation* reactions involve introduction of the cyanoethyl group ($-CH_2CH_2CN$) into other molecules.

Reactions of Acrylonitrile

Olefinic Reactions

1) $CH_2{=}CHCN + HOCl \rightarrow HOCH_2\overset{OH}{\overset{|}{C}}HCN$
2) Polymerization
3) Copolymerization

Cyanoethylation Reactions (base catalysis)
$CH_2{=}CHCN + ROH \rightarrow ROCH_2CH_2CN$

Nitrile Reactions
$H^+ + CH_2{=}CHCN + H_2O \rightarrow CH_2{=}CH\ COOH + NH^+_4$

Two special cases of olefinic reactions, poylmerization and copolymerization, bear particular mention. Currently the bulk of all acrylonitrile is reacted by these two methods.

Polymerization of acrylonitrile means reacting the chemical with itself. The product of this reaction is hydrolyzed to become a polyelectrolyte resin which is useful as a soil conditioner and as a modifier for oil well drilling muds.

Products of copolymerization reactions are even more useful and represent what is by far the biggest market for acrylonitrile today. Of these copolymerization products, nitrile rubber and synthetic fibers are the big ones.

Polymerized with butadiene, acrylonitrile forms an excellent non-oxidizing, oil-resistant rubber. Its uses include gaskets, hoses and electrical insulation.

(Continued on Page 75)

CAST IRON PIPE . . .
Arteries of American Cities

• By Wallace T. Miller
MEMBER OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

If we were able to see under the pavements of the modern American cities, we would really be surprised at the extent of underground piping. Water, gas, sewage and steam are some of the more important materials transported in this manner. These mains are of prime importance to our very existence—literally the arteries which distribute what might be called the "life-blood" of the American community.

The most common material used in underground mains is cast iron pressure pipe.

Iron was known to man in prehistoric ages. The iron column of Delhi, in India, a Hindu monument about sixteen inches in diameter and fifty feet long, is believed to have been erected about 1,000 B.C.. The ability to cast pipe probably developed from the manufacture of cannons. Iron cannons were used as early as 1313 A.D.

Iron water pipes were mentioned in German records as early as 1455. In 1664 King Louis XIV ordered the construction of several mains, fifteen miles in length, to supply water, under pressure, for the fountains and town of Versailles. These mains are still functioning after more than 290 years of service. At the time this pipe was cast, the production of iron required the use of expensive charcoal in reducing iron ore. In 1738 lower cost iron was produced in England using coke instead of charcoal. The introduction of cast iron pipe on the North American Continent occurred in Montreal in 1816.

Cast iron, steel and wrought iron are all commercial forms of iron. Each exhibits distinct physical characteristics with a wide range of values. Cast iron lends itself readily to the formation of intricate shapes and has always been a metal of wide usefulness. Its outstanding merit is its resistance to corrosion when used for conduits in the form of cast iron pipe and fittings.

Cast iron is a carbon-iron alloy containing varying amounts of silicon, manganese and other elements. In gray cast iron, a major part of the carbon content occurs as free carbon or graphite in the form of flakes. These flakes are interspersed throughout the mass of metal. The appreciable volume of graphite flakes makes gray cast iron more resistant to corrosion than the purer forms of iron. When, under unusual circumstances, cast iron corrodes, the products of corrosion adhere tightly to the surface and thus help to protect the metal underneath. In severely corrosive conditions where the metallic content of cast iron pipe may be reduced by corrosion, the corrosion products form an interlocking mat of graphite, phosphides and iron oxides which is strong and dense. This enables the pipe, under ordinary pressures, to continue to serve indefinitely as an effective conduit.

The graphite flakes in cast iron improve the machinability of cast iron. In drilling, tapping or cutting with ordinary tools, the graphite flakes break up the chips and lubricate the cutting tool. At any particular hardness level, cast iron is more easily machined than most other metals.

Steel and wrought iron, the two other commercial forms of iron, are made by reducing the non-ferrous constituents of pig iron. As compared with cast iron, the most marked changes caused by these conversions are an increase in strength, ductility, and forging properties, and a loss of the original granular structure with an accompanying loss of corrosion resisting qualities.

At high temperatures, iron has a strong tendency to alloy with many of the non-ferrous substances, present in the fuel or ore. These are retained in the cast iron. They are not injurious because each has a particular modifying influence on the metal. The foundryman controls these constituents scientifically to produce the desired qualities in his castings.

The major non-ferrous elements found in cast iron pipe and their general effect may be briefly stated as follows:

Carbon may vary from about 3.00 to 3.75 percent by weight. High carbon means soft iron and low carbon means hard iron.

Silicon normally ranges from about 1.00 to 2.75 percent. Silicon promotes graphitization. Other conditions being equal, high silicon will make the iron softer. This element is very useful to control the properties of iron in thick and thin sections.

Manganese is usually within the range of 0.20 to 1.00 percent. It is used in minimizing the deterimental effects of sulphur.

Phosphorous is usually between 0.10 and 0.90 percent. Phosphorous increases the fluidity of the molten iron, making it easier to pour at low temperatures and better for casting thin sections. Above 0.15 percent it forms iron phosphides, which are hard, wear-resistant, and corrosion resistant. A medium-to-high phosphorous content is often preferred for cast iron pipe.

Sulphur was formerly controlled by maintaining a range under 0.10 percent. By balancing sulphur with manganese, sulphur contents up to 0.12 percent may be found in high quality irons.

Innoculation, a common practice in the manufacture of cast iron pipe and fittings, is done by the addition of small amounts of graphite or ferrosilicon, which addition alters the structure of iron by an amount out of proportion to concentration of these elements. The practice is very beneficial and widely used to promote uniformity of product.

Casting Methods

Cast iron pipe was cast in horizontal molds, in lengths of from four to five feet in the earliest days in Europe, and in nine foot lengths up to about 1855. The mold was formed in two boxes of damp sand. Each box contained an impression of half the outer circumference of the pipe. The two half-molds were closed around a core, a cylinder of baked sand reinforced with iron rods, the diameter of which was the same as the pipe bore. The length of the pipe was limited by the length at which the core would support itself without bending.

Increasing the length of pipe, with the reduction in the number of joints, was effectively accomplished with the development of vertical pouring, or pit casting. The length was then increased to twelve feet and later to sixteen feet. The vertical method of casting is still in use today, chiefly for large diameter pipe.

Today most cast iron pipe is made by the centrifugal method of machine casting, using either sand lined or metal molds. Except for the particular method of casting, the essential operations are basically the same in all foundries.

The modern pipe foundry is arranged to receive raw materials at one end of the plant and to deliver finished product at the other end. The furnace used for melting the iron is called a cupola. This is a steel shell, lined with firebrick, from 5 to 10 feet in diameter, and about 40 feet high. The charges of raw material usually enter the cupola at a point about half its height, the upper portion serving as a draft stack. The process of melting is somewhat similar to the blast furnace, but does not provide for use of the exhaust gases.

In starting the process, a bed of coke several feet thick is placed in the bottom of the cupola and ignited. The cupola is then filled with alternate charges of coke, limestone, pig iron and scrap. A blast of low-pressure air is introduced through openings near the bottom. In a short time, molten iron begins to flow out of an opening near the bottom. Slag is drawn off through an opening higher up. As the process continues, additional charges of raw materials are added, each charge being accurately proportioned by weight.

There are several types of cupolas and some slight variations in the process used in obtaining molten iron. In most types, the cupola is operated continuously for a period of not more than 24 hours, and a portion of the shell is relined before re-use. By the use of metallurgical controls, precise knowledge of the physical characteristics of the iron is obtained before it is poured into the mold. The temperature of the molten metal, as it comes from the cupola, is between 2300 and 2500 degrees. It is drawn off into large ladles for transportation to the casting floor.

The metal mold centrifugal process consists of a machine in which the pipe is cast within a cylindrical metal mold, mounted on rollers and in a water jacket, with provisions for rotating at comparatively high speeds. A hydraulic cylinder or mechanical drive is utilized to move the entire assembly longitudinally. Molten metal is fed into the mold through a trough. A pouring ladle is used to discharge an amount of metal, sufficient to pour one length of pipe, into the trough. The flow of metal is controlled at a constantly uniform rate. The trough is stationary while the mold has not only a rotary movement but moves at a constant, predetermined speed away from the trough during the pouring operation. The stream of metal coming from the trough impinges upon the mold, is held in place by centrifugal force and forms a homogeneous pipe with a perfectly cylindrical bore. The pouring rate of the casting ladle and the travelling speed of the mold assembly can both be accurately regulated to provide any required wall thickness within desired tolerances.

After casting, the mold continues rotating until the pipe has cooled to approximately 1500° F. After being taken from the mold, the pipe passes through a closely regulated heat treating furnace, is heated to approximately 1750° F. and is slowly cooled below 1200° F. before leaving the furnace.

In the sand lined mold process, the pipe is also cast centrifugally but in sand lined molds. The mold is prepared by means of a flask placed in a vertical position, with a metal pattern being centered within the flask. Tempered and bonded foundry sand is packed firmly between the pattern and flask with pneumatic rammers. After the pattern is removed, the sand is surface coated, the mold is dried and is then ready for transfer to the casting machine.

The casting machine and the casting process is very similar to casting in metal molds. When the spinning metal has solidified the pipe remains in the mold until cooled to a temperature of about 1200° F. The pipe is stripped from the flask by breaking loose the sand mold.

The average citizen is afforded little opportunity to observe the network of underground piping which precedes the development of our community streets. Occasionally we might be permitted to obtain a very limited view when excavations are made for new service connections to the various mains, or other routine work is undertaken. Sewer man holes reaching the surface of the streets give evidence of the existance of sewer mains, carrying domestic and industrial wastes, as well as storm water drainage. The modern sewerage system frequently includes the use of pressure sewers and cast iron pipe is often used for this type of construction.

America's first piped water supply was built in Boston in 1652. More than 17,000 communities in the United States now have public water works systems. Over 100 million people are served by these systems, which supply more than 17 billion gallons of water daily. Practically all of these have been developed during the last century and a half.

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A Case Study

(Continued from Page 51)

causing the component parts of the construct to be mutually incompatible.

Lavoisier was aware of the weakness of the former concepts of element and ignored them in all his work. By means of operational data alone, he constructed a valid and entirely successful concept. In his definition:

> . . . we must admit as elements, all the substances into which we are capable, by any means, to reduce bodies by decomposition. Not that we are entitled to affirm that these substances we consider as simple may not be compounded of two or even of a greater number of principles; but, since these principles cannot be separated, or rather since we have not hitherto discovered the means of separating them, they act with regard to us as simple susbstances, and we ought never to suppose them compounded until experiment and observation have proved them to be so.[3]

is seen a construct typical of operational definitions. The distinguishing characteristic and successful mark of Lavoisier's definition of element is its completely empirical aspect. He depended on no preconceived philosophical notions of matter, as did Boyle. Looking on reality, Lavoisier, in contradistinction to Boyle, neither expected to abstract an inner nature or essence, nor did he attempt to read into reality its ultimate constitution. He bypassed the phlogistonistic method of common-sense observation and relied solely on the readings of a balance or the measure of a weight in a purely experimental scheme.

[3] Antoine Laurent Lavoisier, "Elements of Chemistry," *Great Books of the Western World*, ed. by Robert M. Hutchins (Chicago: Encyclopedia Brittanica, 1952) p. 3-4.

The operational type of definition such as Lavoisier's has lines of reference directly to reality through experiment (double lines in Figure II).

Certain philosophical truths are necessarily at the basis of all interpretations of experience, whether the knowledge is acquired by means of an ontological or a constructural method. Such truths are the existence of real beings outside the observer, principles of identity and of contradiction, order in nature, etc. To these Lavoisier added the Law of Conservation of Mass (LCM), assuming it as true and as underlying his theory and experiment. Though the Law was never explicitly formulated by Lavoisier, the concept of permanence of matter was implicit in all his work.

Figure II demonstrates the validity of Lavoisier's concept. It shows the logical connections to other concepts and direct connections to reality through the experimental operations in the definition. The range of applicability is throughout the field of experimental and theoretical chemistry, while the simplicity of the concept guarantees its practical advantage over all earlier elementary concepts. Empirical verification, strictly speaking, is a necessary corollary of the operational definition, assumed in the technique employed in the method. The concept is internally consistent since it is a purely empirical construct with no opposing constituents in the operations involved: a substance was to be called an element until it was proved to be compounded. Lavoisier's concept signalized the close of the hundred years' gap in chemical science.

The analysis of the concept of element indicates that in the seventeenth and eighteenth centuries, the danger to knowledge lay, not in the use of the scientific method to discover ontological truth, as the problem is seen today, but rather in the application of philosophical methods for the obtaining of scientific truth. Philosophical questions require a philosophical method in their investigation, as scientific questions demand a scientific method. Confused methodology led to the century-long stalemate in chemistry. With the freedom gained by a strictly empirical method, chemistry has, from Lavoisier's day, enjoyed a progress constantly accelerated by the discriminating use of the constructural method of dealing with experiment. ●

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Facts and Fancies About Fats

(Continued from Page 54)

acid, and protein; (7) promote growth and increase living protoplasm; (8) help keep the body cooler in warm weather; (9) prevent body heat loss in cold weather; (10) protect delicate organs; (11) improve reproductive capacity; (12) increase physical capacity.

In a few years, it is anticipated that acetin fats will be widely used by the margarine industry. This "acetin" margarine should require little or no refrigeration. A spread which does not become rancid, which spreads easily when cold, and which does not become fluid when warm should have high consumer acceptance.

Short-term feeding studies indicate that, calorie for calorie, acetin fats are fully as nutritious as the triglycerides from which they are prepared. There is no reason to believe that acetin fats are any less nutritious than hydrogenated triglycerides, since the end products of the digestion of acetin fats are fatty acids, glycerin and acetic acid (vinegar acid).

Bread and Spread

Bread and spread have a great potential in the diets of the American people. They are nutritionally complementary and benefit each other. They are among the cheapest food sources of calories, protein, calcium, iron, Vitamin A, thiamine, riboflavin, and niacin. Together with ascorbic acid and Vitamin D_2, these are the nutrients most commonly deficient in the diet.

The relationship of flour, bread, margarine, and spread consumption is shown in Figure 1. It would appear that the "ceiling" for spread consumption is above 20 pounds per year and that this level cannot be reached easily without greater consumption of bread.

Over a period of years, however, the total consumption of bread in this country has been declining. At the same time, the total calorie consumption per capita has remained essentially unchanged. During this period, the financial status of the average consumer has increased greatly, and more money is available for food purchases. Compared with fourteen years ago, the average American spends 50 per cent more of his income to buy a greater variety of foods. At the same time, he eats nearly 100 pounds more food per year, but the same number of calories (i.e.: 3100-3150 per day).

One of the reasons for the significant drop in bread consumption may be historical. The unenriched white bread produced in this country between 1880 and 1941 was inferior nutritionally; mild vitamin and mineral deficiencies were rampant. As the science of nutrition developed, it became evident that people who consumed large amounts of this bread risked malnutrition. Therefore, the public was educated to eat more vegetables and other "protective foods" to obtain the vitamins and minerals that were removed in flour milling. Since the desire for food is limited by the narrow capacity of the human stomach, people were forced to eat less bread.

By 1940, most of the vitamins essential to man had been discovered and chemists had learned how to synthesize many of them. It became possible, therefore, to enrich bread with vitamins and minerals, thereby restoring those critical nutrients that had been removed in milling. In 1941, the enrichment of all white bread with specified amounts of thiamine, riboflavin, niacin, and iron became mandatory. The addition of calcium and Vitamin D was made optional.

Few people today realize that, with the advent of the "enriched bread era" the urgent need for green and yellow vegetables in our diet (so important to good nutrition during the "protective foods era") has disappeared.

Figure 2 shows the nutritional value of 6 slices of bread, 6 pats of spread, one quart of Vitamin D milk, and 6 ounces of orange juice. This is an excellent diet which can be made completely adequate by the addition of two eggs and a serving of meat. Vegetables, it will be observed, are not necessary. These data help to show just how nutritious bread and spread really are.

I am not suggesting that anyone should attempt to live on this diet, good as it is. For psychological and physiological reasons, it is desirable to eat a variety of foods. I only wish to demonstrate that an excellent, inexpensive diet in the United States can be based on bread and spread, milk and citrus. This is the basic diet from which departures can be made.

A great deal has been said by pseudoscientists and "amateur" nutritionists about the hallowed virtues of whole wheat and the "hallowed" weaknesses of white bread. I have studied these claims thoroughly and have found them untrue. Enriched white bread, made as it is today with 4 to 6 per cent nonfat milk solids, is nutritionally superior to any common wheat bread of the past and to the standard "whole wheat," rye, or pumpernickel breads of the present.

Enriched white bread, unlike its "emaciated" predecessor, is much more than a pleasant source of calories. It is rich in thiamine, riboflavin, niacin, iron, and calcium. Eaten with spread, it is also rich in Vitamin A. Moreover, it is an inexpensive way to improve the diet.

The public deserves forthright, factual rebuttals to the popular fallacies and the claims of false "prophets" that still persist.

The faith of the American people in enriched white bread as the true "staff of life" must be restored.

The bread industry and the spread industry would do well to consider a collaborative promotional campaign for the consumption of *more daily bread.* ●

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Nearly every great discovery in science has come as the result of providing a new question rather than a new answer.

—Paul A. Meglitsch
Drake University


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Galileo and Scripture

Modern experimental science may be said to begin with the seventeenth century. Its first great exponent was Galileo. The discovery of the telescope opened up a whole new firmament to the gaze of men. Jupiter and his satellites, the phases of Venus, so like those of the moon, all supported the idea that the moon went round the earth. It is impossible for us to realize the effect these discoveries had on contemporary thought—especially in the case of those who had never looked through a telescope. Now, the curious thing is that none of the proofs brought forward by Galileo are capable of demonstrating the fact that the earth does go round the sun, and not the sun round the earth. We cannot here go into the controversy of Galileo. His mistake was in basing his proofs on Holy Scripture. One of his friends writing to him said:

> The Lord Cardinal Barberini who, as you know by experience, has always admired your genius, told me only yesterday evening that he thought it would be the more prudent course in dealing with these matters not to go beyond the reasons given by Ptolemy or Copernicus, nor to employ any other except physical or mathematical arguments. The theologians consider that it is their province to expound the Sacred Scriptures . . .

Another wrote.

> Cardinal del Monte told us that he had discussed the question of Copernicanism at great length with Cardinal Bellarmine, and that he had concluded as follows. If you treat the system of Copernicus and set forth its proofs without bringing in the Scriptures, the interpretation of which is the business of qualified theologians, then you would not be opposed in any way whatever . . .

The whole question of the condemnation of Galileo has often been dealt with. The discussion has made it clear to all impartial minds that the infallibility of the Church was in no way compromised, though the foresight and enlightenment of a Roman Congregation at a given moment were not equal to the demands made upon them. The matter is here referred to because it is the only example of the apparent hostility of the Church to scientific progress.

—Henry V. Gill, S.J.,
"Fact and Fiction in Modern Science"

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New Books

Photo by Vic Kelley

Science for Modern Living, Elementary Series, *2nd Edition* (1956)

- *By* SMITH, CLARKE, HENDERSON, and JONES. A Series of Science Readers. *Science Along the Way,* (Grade 1) $1.64. *Science Under the Sun,* (Grade 2) $1.76. *Science Around the Clock,* (Grade 3) $1.88. *Science Across the Land,* (Grade 4) $2.00. *Science Through the Seasons,* (Grade 5) $2.16. *Science Beneath the Skies,* Grade 6) $2.28. Teacher's Manuals for each grade in preparation. J. B. Lippincott Company, New York, 1955.

If reading about such science and nature-study topics as animals, flowers, water, earth, magnets, electricity, the seasons, bicycles, stars and cameras can bring a child to a better understanding of his environment, *Science For Modern Living,* a series of science readers, will supply the information. Although first-hand experiences through observation and the manipulation of organized materials are necessary, especially in the elementary grades, children must still depend a great deal on printed materials for their science learnings.

This newly revised series makes nature study interesting and vivid for primary-school children by examining the familiar elements of the immediate environment such as weather, birds, insects, etc. For the intermediate grades, units which range farther afield such as state and national parks, airplanes and science fairs are provided. The selection of illustrated topics, the limitation on content, and the graded vocabulary reveal the authors' concern for accomodating the matter to both the interests and the maturation level of most elementary-school pupils.

The style of writing might be called the descriptive-narrative type, interspersed with conversational dialogue for a touch of intimacy. The sentences are short and direct. Explanations clear. Throughout the progression of topics the vocabulary is controlled, with books 1 and 2 terminating in numbered work lists and the others in a well-organized glossary of difficult words found in the book.

Accurate illustrations in black and white and the two and four-color printing processes abound. The illustrative material is, in most cases strategically placed so as to be visible while reading the appropriate text.

The usual study helps are found at the conclusion of the chapters. Here are suggestions for: "Things to Remember," "Things to Think About," "Things to Do," and a vocabulary test called "Using Science Words." Among these are some helpful suggestions to further activate the pupil. However, teachers and pupils, either individually or together, should carefully select from such arrays of suggested activities. It is not intended that all the recommendations thought up by a group of authors, be followed or that all could or would be meaningful to every individual or class of individuals. Overdoing such teacher aids, especially the more impractical ones, creates problems such as time wasting through busy work.

Francis Kleyle, Ph.D.
School of Education
Duquesne University

Science for Modern Living Junior High Series

Exploring Modern Science	353 pp.—$3.00
Enjoying Modern Science	466 pp.—$3.20
Using Modern Science	654 pp.—$3.80

- *By* VICTOR C. SMITH and W. E. JONES in consultation with W. R. Teeters. J. B. Lippincott Company, New York. 1956. Second Edition.

Science for Modern Living is a series of three books and includes Exploring Modern Science, Enjoying Modern Science, and Using Modern Science. These books have been designed for seventh, eighth and ninth grades respectively. The aims of the series are to assist the student to develop an understanding of his environment in terms of scientific principles and their functional application to problems of everyday living; and to stimulate learning and problem solving by the use of the scientific method through the medium of the student's interest.

In content, the amount of material covered is greater than is usually found, the style is interesting and informative; the vocabulary, terms and definitions seem to be within the scope of the grade levels for which they were intended.

The informational material is accurate, current, scientific and functional. It is conducive to the formation of sound scientific attitudes and meaningful as a mode of interpreting human experience.

The textbooks are organized into comprehensive units of not more than two chapters which in turn are subdivided into problems. Each problem may adequately serve as one day's work program. The problem ends with a thinking-matching exercise for notebook work, as well as with suggestions for teacher and/or pupil

demonstrations which are within the range of the physical facilities of most schools and adapted to the experiential level of the pupils. At the end of each chapter are a review, a word study list, thinking exercise, discussion topics and student reference books. All of these are directly related to the material covered.

The illustrations are numerous and pertinent, many reflecting important technological application of the data involved. The accompanying descriptions are adequate. Aids to assist in the use of the textbooks are (in addition to those indicated above) a film list for each chapter, a glossary with pronunciation key, a table of contents and a general index.

The mechanical features of the books are good. They are well-bound in attractive cloth suitable to the subject matter. They are easy to read and the paper is of a good quality with a non-glossy, smooth finish.

It is the opinion of these reviewers that this series of textbooks:

(1) Fulfills the aims as stated by the authors and conforms to the purposes of general science instruction in education in terms of subject matter content and in the broader implications of living.

(2) Represents a valuable instructional instrument in informational material, accuracy, content, organization and in illustrations, exercises and demonstrations at both the teacher and pupil levels.

(3) Presents material that is adaptable to pupil needs in terms of maturity levels and interest, and facilitates the articulation and integration of the subject matter from grades seven through nine for both student and teacher.

(4) Would ably assist the pupil to develop an increased accumulation and comprehension of scientific data; a better understanding of themselves and their complex environment; and a more functional approach to the methods, techniques, and applications of scientific learning.

Letizia Zito, Secretary
Samuel Golden, Chairman
Committee Members:
Nancy Hanlon
Doris Lee Heil
Jay Lowery

The Flood and Noah's Ark
The Tower of Babel

• *By* ANDRE PARROT (Translated from the French by Edwin Hudson) New York: The Philosophical Library, Inc. 1955. Pp. 76 and 75 respectively. $2.75 apiece.

With these two volumes Andre Parrot continues the proposed "Studies in Biblical Archeology" introduced by his *Discovering Buried Worlds* (SCIENCE COUNSELOR, Dec., 1955.) Here two of the Bible's most fascinating stories pass through the sifting hands and searching eyes of the archeologist who retells them with an artist's pen and a Christian's respect. One needs more than a superficial interest to be drawn and held by the scientific handling of stories children have long listened to. Given the initial interest, however, Mr. Parrot develops it through discoveries and manuscripts and ruins, without creating the musty atmosphere the layman associates with such ventures. He speaks with language proper to his field, but adapts it well to a wider audience. The text and illustrations give facts the amateur can comprehend; the bibliography offers sources the expert can consult.

We learn of a collection of texts from both biblical and Babylonian literature containing the essential points of the flood narrative. We consider also archeological documentation of the cataclysm and speculation on what might have been the structure of the ark. In the closing pages the author handles reverently the religious aspect of the flood and presents himself honestly as a scientist, desirous of avoiding mixing dogmatics with archeology.

The Tower of Babel Mr. Parrot likes to consider "as a hand stretched out in supplication" rather than "a clenched fist raised in defiance to heaven." This thesis has already roused opposition and raised objections. He makes his answer a seeking for synthesis and the middle road. His search proves an interesting and rewarding journey with a competent and companionable guide.

In the foreword to *The Flood and Noah's Ark*, Mr. Parrot makes this statement:

> . . . my enthusiasm remains undimmed, as does my conviction that the believer has nothing to fear and much to learn from the resurrection of the biblical past under the pick of excavators. The important thing is not to read into the documents what is not there. If one tries to prove too much from them, one finishes up by proving nothing at all, at the same time bringing discredit on a science whose discoveries are imposing enough to do without specious adornment.

His healthy attitude is reflected in his works, which will do much toward striking the happy balance between science and faith.

Joseph A. Healy, C.S.Sp.
Duquesne University

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A Young Chemist's Visit

(Continued from Page 68)

"A physician friend, Dr. Carl Heise, induced by the striking action of these plants, has carried on a very comprehensive investigation and has proved that only these three species have the ability to dilate the pupil. All other plants, and he has tested innumerable ones with respect to their action on the cat eye, have proved completely inactive, with the exception of a few which show the opposite effect, namely a contraction or diminution of the sight hole, such as aconite, for instance."

"Indeed," he replied, "In this you have perhaps found a true antidote for the harmful effects of belladonna, etc. Try this and study the action on the cat eye of these antagonistic plants applied in succession or at the same time. The problem has its difficulties, but you will overcome them. Now tell me, how did you come to take up this unique kind of organic chemistry?" (Goethe was using the term 'organic' in the then current meaning of action on the organism.)

Döbereiner had asked me the same question but I had never told him all the details. Accordingly, I was glad to relate the whole story to Goethe because I was certain that it would arouse his lively interest.

Runge then told Goethe his experiences as an apprentice in the apothecary's shop in Lübeck and how he had accidentally discovered the dilating action of hyoscyamus on his eye.

After Goethe had expressed his great satisfaction with the story of the young man whose life had been saved by means of the induced artificial black cataract, and had thanked me for all I had told and showed him, he presented me with a package of coffee beans that a Greek had sent to him as being of especially fine quality. "You can use this likewise in your researches," he said.

He then dismissed me. Without really knowing how I did it, I found myself out of the door and down the steps, when Goethe called after me: "You have forgotten your assistant." The servant then put in my arms, the little tomcat, who had quietly sat on the sofa during our conversation.

So I had really been received by Goethe and had been favored in a manner whose significance did not become actually apparent to me until on my way home I was greeted with undisguised envious looks by acquaintances and friends who overwhelmed me with questions. Oddly enough, they did not ask what Goethe really wanted with me and what the cat had to do with the matter; they were anxious to hear how he had greeted me, whether he had been cordial, whether he had offered me a chair, and so on. I could not account for this line of inquiry. I had been so immersed in my subject and Goethe had been so attentive and cooperative that I had had no time for such nonessentials. I noticed nothing of the aloofness and gruffness of which so many complained and which they doubtless brought on themselves. Goethe may have been cold and reserved when visited by curiosity seekers, the scourge of famous men, and of whom even Voltaire complained. Such people brought nothing, they merely wished to receive. But I gave with lavish hands and captured his keen scientific attention to things which were new to him and whose importance became clear to him at once.

In contrast to Runge's detailed account, Goethe's "Tagebuch" contains for October 3, 1819 the simple entry: "Junger Chemikus Runge." The latter completed the recital: "As to the coffee, Goethe was correct, because I soon discovered in it the now familiar 'caffein' because of its high nitrogen content." In a letter, now preserved in the Deutsches Museum in Munich, Runge wrote to Döbereiner from Berlin, March 12, 1820. "Will you kindly transmit to His Excellency, the Privy Councillor von Goethe the following information with my compliments. The Mocha coffee which he so generously gave me is now being studied; the analysis will be published in the second number of my Phytochemical Discoveries." Runge is referring here to his youthful ambitious project: *Neue phytochemische Entdeckungen zur Gründung einer wissenschaftlichen Chemie*, a periodical designed to be the repository of all discoveries in the field of plant chemistry. Only two numbers appeared, and apparently Runge bore the expenses from his meager means. The discovery of caffein (originally called 'Kaffeebase') was paralleled by his discovery of quinine in cinchona bark. The extract of the bark was treated with acidic then alkaline lead acetate and the filtrate boiled down to secure "the active basic constituent." (This discovery is usually credited to Pelletier and Caventou, but Runge's report in 1819 precedes their account by a year.)

Runge had decided to go back to Berlin to study medicine and science. In fact, only four days after his first visit to Goethe, the latter's diary for October 7, 1819 contains the note: "The chemist Runge from Hamburg; to take his leave." This was probably a purely formal audience and Runge has left no record of this final visit.

Accordingly by 1820, the young Runge had made a considerable number of important discoveries but he was still ambitious to train himself for further triumphs. These eventually included the independent discovery of aniline (he was preceded by Unverdorben), phenol, rosolic acid, pyrrole, the first coal tar dye, the foundations of paper chromatography, and others. These achievements belong to his later period, which will not be dealt with here.[4] But enough has been given to show his genius and brilliance and to demonstrate how these combined with hard work and enthusiasm yielded a rich harvest to a modest student.

In 1865, Runge was made honorary member and master of the famous Freien Deutsche Hochstifts at Frankfurt am Main. The diploma bore the following well deserved quotation:

"Wer will Lehrling sein?
Jedermann.
Wer soll Geselle sein?
Wer was kann.
Wer soll Meister sein?
Wer was ersann."
—*Goethe*

LITERATURE

1. F. F. Runge, "Hauswirtschaftliche Briefe," Berlin, 1866.
2. G. Lockemann and R. E. Oesper, "Friedrich Stromeyer and the History of Chemical Laboratory Instruction." J. Chem. Education **30**, 202 (1953).
3. W. Prandtl, J. W. Döbereiner, Goethe's Chemical Advisor, J. Chem. Education **27**, 176 (1950).
4. For more detailed accounts of Runge's life see: M. Rehberg, "F. F. Runge, Sein Leben und Sein Werk" Oranienburg, 1935; B. Anft, "F. F. Runge, A Forgotten Chemist of the 19th Century," J. Chem. Education **32**, 566 (1955).

★ ★ ★ ★ ★

The chemical industry supplied direct employment to more than 810,000 men and women including over 540,000 production workers. Average weekly earnings for hourly rated workers in September were $84.25, more than matching the generally higher wage trend for all manufacturing industries.

In August the chemical industry separation rate was 1.8 per 100 employees compared with 4.1 per 100 for all manufacturing—over-all, the industry has the second lowest industrial labor turnover rate.

Chemical News

Plan A Field Trip

(Continued from Page 44)

A brief discussion should follow the movie thus giving the students a knowledge of the Natural Gas Industry before certain phases are to be seen on the field trip.

II. Day of field trip—locality will determine sequence of trip and the places to visit.

Briefing of field trip plans in class just before starting trip is important. A schedule and program outline should be given to each student during the briefing. Schedule should give starting time, scheduled stops and what will be seen, time and place of lunch, and return time.

	Optional
—Drilling for Gas	Propane Plants
—Compressor Station	Gasoline Plant
—Underground Storage	(if available in area)
—City Measuring Station	
—Meter proving and Repair Shops	Land and Lease Billing Department
—Gas Dispatchers Office	Chart Room Map Department

Sample Program

Name of School_____________________ Date__________

Morning Schedule—

9:00 Briefing of the trip and assignment of groups to each trip guide. One commentator is in charge.

9:10 Board Bus

9:45 Drilling for Gas
Explanation of drilling procedures and observe working procedures.

10:05 Board Bus

10:30 Visit to Compressor Station
(explain gasoline extraction if such a plant is near or a part of compressor station)

11:30 Luncheon and Rest
(give location)

12:30 Board Bus

12:45 Underground Storage Plant

1:30 Board Bus

2:00 City Measuring Station

2:15 Board Bus

2:30 Meter Shop

3:15 Board Bus

4:00 Back at School

Note: Starting time and scheduling will vary with each locality.

III. Day after Field Trip.
Class discussion of trip.
Written report of field trip. ●

Power from the Atom

(Continued from Page 41)

or other atomic fuel is in the form of separate elements, in a matrix of graphite, or any other material used as a moderator to slow down the neutrons to the speeds at which they will be most effective.

In a homogeneous reactor, however, the fuel is in the form of a uranium salt, dissolved in water, so fuel and moderator are all mixed together. The "HRE," at Oak Ridge, used an aqueous solution of uranyl sulfate, enriched so that more than 90 per cent of the uranium was the U-235 isotope. The chain reaction, then, would occur in this uranium "soup," which would thereby be heated. Being kept under 1000 lbs. per square inch pressure it could be raised to 482° F and still remain liquid. This hot solution was then pumped to the heat exchanger where steam was generated. In 1954 the HRE was dismantled to make room for a new "Homogeneous Reactor Test" on a larger scale.

The heat exchanging stage, of course, is an added complication. It increases the expense of a plant, and some energy is lost in the process. Consequently engineers have looked longingly at the idea of a plant in which water would go into the reactor and come out steam, ready for use, just as it does from the boiler of the ordinary plant, fired with coal or oil.

When knowledge of what happens in a reactor was much more limited than it is now, it was supposed to be very hazardous to allow water in a reactor to boil. The formation of bubbles, it was feared, would give rise to an instability which would cause the activity in the reactor to increase suddenly, and possibly cause an explosion.

However, experiments made at Arco showed that boiling water in a reactor will decrease the activity. This is largely because bubbles of steam take up some of the room where there would otherwise be water. With less water present to stop them, more neutrons will escape and be ineffective. As activity is reduced, the temperature likewise is lowered because less heat is produced by fission. The water boils less rapidly, there are fewer bubbles, and the rate of fission is again increased. In this way the boiling water reactor tends to be self-regulating, and maintain itself at the desired degree of activity.

Steam so generated is radioactive, which means that the pipes carrying it to the turbine—and those through which the condensed water returns—must all be shielded. So must the turbine itself, while in operation. Fortunately, however, radioactive steam does not impart any significant radioactivity to the turbine and piping. A few minutes after shutdown, the turbine may be approached freely for maintenance.

The largest atomic power plant now projected is one for the Commonwealth Edison Company of Chicago, and a group of seven associated companies, which will

be built, entirely with private capital, by the General Electric Company. This is designed to deliver 180,000 kilowatts of electrical power.

It is a boiling reactor, but goes one step farther, by using a dual cycle. That is, steam will be taken out of the top of the reactor, at some 600 pounds per square inch pressure. At the same time, according to the original plans, some of the heated water would be taken out at a lower level. Because of the pressure, it is superheated, i.e., its temperature is well above the normal boiling point of 212 F. Admitted to a "flash tank," where pressure is relieved, the water "flashes" into steam, at 350 pounds per square inch. The 600-pound steam is admitted to the high-pressure end of the turbine, and that at 350 pounds to the middle, at the low-pressure stage. In this way more efficient utilization of the energy generated is attained, and there are also some operating advantages.

It is estimated that the Commonwealth Edison plant will cost about $45,000,000, which would come to $200-$270 per kilowatt of net output. This compares with $150 per kilowatt for a comparable plant using coal. However, it is believed that within a few years the nuclear fuel may be obtained at a cost of 2 mills per kilowatt-hour produced, as compared with 3.1 mills for coal, so even this first plant will compare favorably with present-day practice.

When we consider the great improvements that have come in power production over recent years, increasing the efficiency and reducing the costs, it certainly seems reasonable to expect that atomic plants will be similarly improved, over this first installation.

Many attacks are being made on the problem. Another large atomic plant, planned by the Consolidated Edison Company of New York, will be located on the Hudson River, near Peekskill, N. Y. Other groups are also making studies. As various methods are tried, and notes compared, there will gradually emerge the atomic plant of the future, which will supply more and more of our needs.

Coal and oil-fired stations will continue to be built, even in increasing numbers, as all efficient sources of power will have to be utilized to fill our requirements. But nuclear power will take over more and more of the load. By 1970, engineers estimate, 14% of the new plants going into service will be nuclear. Once becoming competitive, they will expand rapidly, so that by 1980 about two-thirds of the new plants will run on atomic energy.

These are additions, but let us consider the total capacity in our nation which, at the beginning of 1955, was 102 million kilowatts. Forecasts indicate that this will rise to 375 million by 1975 and 514 million in 1980. Of these amounts atomic power is expected to contribute 40 million in 1975 and 120 million in 1980.

Considering such data, it is small wonder that interest in atomic energy is increasing at such a rapid rate. Truly, the atomic age has dawned, and promises to bring untold peaceful applications. ●

Aspects of Chelation

(Continued from Page 58)

c. Masking agent[22, 23]
d. Polarographic analysis[24]
e. Colorimetric analysis[25]

2. Water Softening[26]
   a. Soap Industry[27, 28]
   b. Textile Industry[29]
   c. In boiler and heating systems for softening water and dissolving scale[26]
3. Stabilization of foods, pharmaceutical products by inactivation of contaminating metal ions which cause precipitation or catalyze decomposition[26, 30-32]
4. Metal cleaning—to remove metallic oxide coatings[26]
5. Biological applications
   a. For the removal of heavy metals from the human body[33, 34]
   b. For dissolving urinary calculi[35]
   c. Anticoagulant[36]
   d. In treatment of hemochromatosis[37]
   e. As decalcifying agents[38, 39]
6. As metal buffering agents in maintaining a nearly constant concentration of metal ion at almost any level of concentration. Such metal buffers may be considered analogous to a typical pH buffer: the metal chelate being analogous to a weak acid and the chelating agent analogous to a weak acid salt[40]
7. Agricultural Applications—for overcoming iron deficiencies by making iron available to plants[41, 42].

The chemistry and applications of chelation, even though well advanced in many fields are, in many respects, still in the embryonic stage and significant advances can be expected in the future. ●

REFERENCES

1. J. Bjerrum, "Metal Ammine Formation in Aqueous Solution," P. Haase and Son, Copenhagen, 1941.
2. G. Schwarzenbach, E. Kampitsch and Steiner, Helv. Chim. Acta, **28**, 828 (1945).
3. G. Schwarzenbach and H. Ackermann, Helv. Chim. Acta, **30**, 1798 (1947).
4. G. Schwarzenbach and E. Freitag, Helv. Chim. Acta, **34**, 1492, 1503 (1951).
5. A. E. Martell and M. Calvin, "Chemistry of the Metal Chelate Compounds," Prentice-Hall, Inc., New York, 1952.
6. R. M. Izatt, W. C. Fernelius and B. P. Block, J. Phys. Chem. **59**, 80 (1955).
7. H. Irving and R. J. Williams, J. Chem. Soc., 3192 (1953).
8. K. H. Gayer, A. Demmler and M. J. Elkind, J. Chem. Educ., 30, 557 (1953).
9. J. J. Lingane, Chem. Revs., **29**, 1 (1941).
10. K. Bril and P. J. Krumholz, J. Phys. Chem., **57**, 874 (1953).
11. J. M. H. Fortuin, P. Karsten and H. L. Kies, Anal. Chim. Acta, **8**, 356 (1954)
12. S. E. Turner and R. C. Anderson, J. Am. Chem. Soc., **71**, 913 (1949).
13. F. A. Long and S. S. Jones, J. Am. Chem. Soc., **73**, 4119 (1951).
14. F. A. Long and S. S. Jones, J. Phys. Chem., **56**, 25 (1952).
15. J. Bjerrum and Nielsen, Acta Chem. Scand., **2**, 297 (1948).
16. Davies and Monk, J. Chem. Soc., 1949, 413.
17. G. Schwarzenbach, "Du Komplexometrische Titration," Ferdinand Enke Verlag, Stuttgart (1955).
18. H. Flaschka, Mikrochemie ver Mikrochim. Acta, **39**, 315 (1952).
19. H. Flaschka, Mikrochemie ver Mikrochim. Acta, **39**, 315 (1952).
20. W. J. Blaedel and H. T. Knight, Anal. Chem., **26**, 743 (1954).
21. G. Schwarzenbach, W. Biedermann and F. Bangert, Helv. Chim. Acta, **29**, 811 (1946).
22. R. Pribil and M. Malat, Collection Czechoslov. Chem. Communs., **15**, 120 (1950).
23. R. Pribil and V. Sedlar, Collection Czechoslov. Chem. Communs., **16**, 69 (1951).
24. R. Pribil and A. Blazek, Collection Czechoslov. Chem. Communs., **16**, 567 (1951).
25. A. E. Harvey, J. M. Komarmy and G. M. Wyatt, Anal. Chem., **25**, 498 (1953).
26. The Dow Chemical Company, Technical Bulletin on "The Versenes."
27. H. Hilfer, Drug and Cosmetic Ind., **64**, 40 (1949).
28. L. F. Henderson, U. S. Patent 2,371,623, March 20, 1945.
29. J. J. Singer and F. C. Bersworth, Am. Dyestuff Reptr., **41**, 365 (1952).
30. E. P. McFee and J. A. Peters, U. S. Patent 2,544,625, May 29, 1951.
31. H. Jager, Pharmazie, **3**, 536, (1948).
32. W. Swallow, Pharm. J., **168**, 467, (1952).
33. S. H. Cohn, J. K. Gong and M. C. Fishler, Nucleonics, **11**, 56 (1953).
34. H. Foreman, H. L. Hardy, T. L. Shipman and E. L. Belknap, Am. Med. Assoc., Arch. Ind. Hyg. and Occupational Med., **7**, 148 (1953).
35. R. F. Gehres and S. Raymond, J. Urol., **65**, 474 (1951).
36. F. Proescher, Proc. Soc. Exptl. Biol. Med., **76**, 619 (1951).
37. M. J. Seven, H. Gottlieb, H. L. Israel, J. G. Reinhold and M. Rubin, Am. J. Med. Sciences, **228**, 646 (1954).
38. L. M. Screebny and G. Nikiforuk, Science, **113**, 560 (1951).
39. H. Spencer, V. Vankincott, I. Lewin and D. Laszlo, J. Clin, Invest., **31**, 1023 (1952).
40. G. Schwarzenbach, Chimia, **3**, 1 (1949).
41. J. Stewart and C. D. Leonard, Citrus Magazine, **14**, 22 (1952).
42. L. H. Weinstein, W. R. Robbins and H. F. Perkins, Science, **120**, 41 (1954).

P. D. S. M. T. A.

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P.D.S.M.T.A. to assume the responsibility of this society. The board agreed to do so.

It is worthy of note that, since 1946, the "Pennsylvania Junior Academy of Science" has sponsored an annual exhibit at Duquesne University where students' projects are evaluated by competent judges. Prizes are awarded to the deserving contestants.

Such enthusiasm soon attracted other teachers and scholars, both religious and secular. These teacher-students, consisting principally of teaching Brothers and Sisters of the Pittsburgh Diocese, met periodically at one or other of the various Mother Houses in Pittsburgh, for example, the Academies of St. Benedict, Mt. Providence and St. Francis, and the boys' high schools Central Catholic and North Catholic.

It was the privilege of Brother Joseph Kuntz, President 1945-1949, to outline the details of the expanding association and to stabilize it. In the midst of his successes, 1949, he was transferred to Dayton, Ohio. However, he left us his plans, good wishes and his big heart.

Revision of the Constitution

Brother Thomas Schick, S.M. became Chairman, 1949. During that year a revision of the Constitution was begun. The following year, during the Presidency of Rev. Ulric Thaner, O.S.B., the revised Constitution was adopted. The second Constitution, with some amendments, continues in force.

An Annual Institute Day, later called "Science Day" was introduced by Sister Gabriella, O.S.F. in 1948. The following year, the first public demonstration was conducted at Duquesne University where everyone is welcome. Many of us recall the delicious turkey dinners that were served on those occasions.

About 1950, regional meetings were substituted for the conference. Tours were made to places of interest, such as Carnegie Tech, Carnegie Museum, Buhl Planetarium, etc. for the purpose of expanding their knowledge either as teachers or students. On January 1st, 1950, The Biology Section of the P.D.S.M.T.A. became affiliated with the National Association of Biology Teachers.

Gradually, "The Science Teachers Institute" came into being. It was revived in 1951 under the title, "Institute for our own Diocesan Teachers of the Biology Section." This was effected through the combined efforts of Sisters Gabriella and Placedes, Fathers Harcar, C.S.Sp., Ulric Thaner, O.S.B. and Brother Dury, S.M.; Alfred Halpern and Dean Muldoon.

Brother Edward Dury, a biologist, assumed the Presidency, 1953-55. He was an energetic leader, and efficiency expert in Science and the Head of the Science Department of the Catholic Schools of the Diocese of Pittsburgh.

In 1951, the Physics Teachers voted to work conjointly with the Biology and Chemistry Department. Now we find the four major sciences working in unison, viz., biology, chemistry, physics and mathematics, affording greater opportunities for a greater good.

These various experiences, possibly more than anything else, have encouraged students of ability to enter contests, such as, The Science Quiz Program in 1953, the Science Fair at the Buhl Planetarium; also the Radio Broadcasts given at Duquesne University, the Annual Contest Sponsored by Carnegie Museum, the American Chemical Society High School Chemistry Contest, the Television School and others.

Implicit in the Constitution is the Mandate to integrate Catholicity with Science and Mathematics, to develop the whole person, to produce intelligent Americans. There we find also these words: "A special object of the Organization shall be promotion of the best methods of teaching these subjects in our Catholic Secondary Schools."

Thus teachers must fit themselves to guide students toward their future career in the choice of courses and in the selection of reading material in accordance with Catholic ethics and principles. It must be mentioned likewise that throughout the active years of its existence, the P.D.S.M.T.A. has undertaken many other

projects, such as, the examination of text books to guard both teacher and those taught; it has built up and revised courses of study; it has drawn up a list of text books to be used in the Diocese of Pittsburgh.

Following out a main feature of the Organization, science and mathematics, teachers gather at their regular meetings to discuss the work they have in common, to exchange methods and ideas, to aid and encourage one another, to make their teaching more effective and their labor more attractive and enjoyable in the great work of guiding and directing those under their care. ●

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ACRYLONITRILE

(Continued from Page 59)

Liquid reaction products of the same two chemicals are being used as coatings to impart slip resistance, run resistance and decreased shrinkage to textiles.

Acrylonitrile also can be copolymerized with vinyl acetate, vinyl chloride and similar hydrocarbons to form synthetic fibers of the Acrilan, Dynel and Orlon types. These fibers, used alone or blended with wool or cotton, impart crease resistance and improved wear resistance to fabricated garments.

Receiving the attention of the entire textile industry today is cyanoethylation. Acrylonitrile will react with cellulosic materials and indeed with almost any organic or inorganic chemical compound containing a labile hydrogen atom to form cyanoethylated products.

Typical of these products is cyanoethylated cotton which resists rot, mildew and heat degradation much better than its untreated counterpart. It also boasts improved dyability.

Cyanoethylation may have similar beneficial effects when applied to other forms of cellulosics—paper, woodwaste and sisal, for example. It's a comparatively new area of industrial interest in which much remains to be learned. Even in the case of the cyanoethylated cottons, there are production problems to be overcome before the process can reach commercial proportions.

Other interesting and growing uses for acrylonitrile (although they are at present much less important in terms of volume) are in the preparation of adhesives and coatings for paper and leather. As a modifier for plastics, acrylonitrile imparts heat resistance, strength and toughness to consumer products. It also significantly improves chemical properties, including resistance to solvents.

Because of its reactive properties, acrylonitrile is being considered by chemists more and more as a chemical intermediate in the preparation of new dyes, pharmaceuticals and a variety of other chemicals.

The versatility of acrylonitrile has given the modern chemist one of his greatest challenges. Striving toward the unmeasured potential which acrylonitrile represents is among his assignments for the future. ●

Cast Iron Pipe

(Continued from Page 61)

To meet the overall needs of the average community, the water plant must supply 140 gallons of water per person each day. Fifty gallons of this is the amount the average American uses at home. The remainder serves our industrial, commercial and public needs. A good water supply attracts industry, and promotes prosperity in a community.

In 1953, an estimate of the current value of the public water supplies of the country totalled 7½ billion dollars. This represented about 75 dollars of investment for every person being served. The major portion of this investment was in underground mains, most of which are cast iron. A recent survey of 25 representative cities showed that more than 95 percent of all the water mains in service, over 4 inches in size, were cast iron pipe.

Gas companies were organized in many of the larger colonial towns soon after 1800. Some of the earlier installations were in Baltimore, Philadelphia, Boston, Charleston, Mobile and New Orleans. Cast iron pipe had previously been used in England for distribution of gas and these new public utilities started off with the same material. Many of these early gas companies are still using their original mains, except where they have become too small to supply the necessary quantity of gas. Cast iron pipe represents a very considerable part of the underground distribution systems in most of the large gas utilities throughout the country.

Today, approximately 10,000 of our American communities are served with gas which is supplied through underground pipe distribution systems. The distribution piping alone totalled more than 288 thousand miles in 1954—enough to circle the earth eleven times. The nation's gas utilities and pipelines added over 24 thousand miles of main to their systems during the past year.

The piping of natural gas to the major population centers and the tremendous expansion of gas for heating have contributed to the spending of over $1 billion for the construction of new facilities and plant expansion each year for the past five years.

Our vast network of underground pipe lines—many of which are cast iron pipe—are literally the "Arteries of American Cities." ●

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The world's oldest insect specimens—their estimated age is 60,000,000 years—have been discovered in Alaska, 150 miles north of the Arctic Circle embedded in amber.

The insects were trapped in the amber during the Cretaceous period and their bodies are extremely well-preserved, reports the Arctic Institute of North America which sponsored the research. Traces of older insect life have been found, but only in the form of fossil impressions. *(UNESCO)*

Educational Testing Catalog

The most comprehensive catalog in the firm's history, and one of the biggest in the educational testing and publishing field, has been published by Science Research Associates, Chicago, it was announced recently by Lee D. Brown, vice-president in charge of sales, advertising, and public relations.

The 112-page, 5½ x 8½ booklet, listing more than 700 tests, guidance booklets, reading development materials, and the complete services of SRA's consulting and survey divisions, contains many new and improved features.

Complete with a glossary, booklet guide, and a table of contents, the new catalog, utilizing the theme "Progress in Education," is divided in seven sections including "Tests," "Professional Guidance Materials," "Guidance and Educational Publications and Services," "Booklets," "Reading Improvement Materials," "Science Studies, Social Studies," and "Survey and Consulting Services."

New tests, booklets and services are outlined for the reader. Complete descriptions of all items, not just listings, and suggestions for setting up reading and guidance programs are also given.

The newly-designed catalog includes samples from tests, a graphic description of tests and their characteristics, a table of contents of new materials, and a post-paid reply card for ordering.

Approximately 36 illustrations are used to picture the various materials. The booklet is bound with a bright sunset red cover and backing.

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"Their" is Word Most Commonly Misspelled

"Their" is one of the words most commonly misspelled not only by elementary school students but by college students as well, W. MacLean Johnson, publisher of "New Goals in Spelling," reveals. Mr. Johnson, president of the Webster Publishing Company, St. Louis educational firm, has just completed a survey of studies of spelling errors in connection with the new edition of "New Goals in Spelling."

Both groups also had trouble with "too" and "there." Despite these findings, many school children are becoming better spellers and readers without copying and memorizing words, he said. Among the suggestions he gives for improving reading are:

Do not force children to learn the spelling of a word by making them copy it many times.

You must get the habit of looking at all words carefully.

Pronounce all syllables and words distinctly. (If you say "supprised," you may spell it that way.)

Actually, Mr. Johnson explains, spelling shouldn't be difficult. There is an amazing phonetic consistency of English, contrary to public opinion. Looking at words as a combination of syllables one discovers that English is 6/7 phonetically perfect.

The "New Goals in Spelling" are edited by Dr. William A. Kottmeyer, assistant superintendent of the St. Louis Public School System, and May B. Lambador.

The technique used in "New Goals in Spelling" differs from the rote memory technique. A pupil is taught to think of the word first in terms of sound, then in terms of the letter that produces these sounds, and to inspect the word to see whether or not the letters that actually compose it are what he, on the basis of the sound-letter-symbols has learned, would expect.

A list of 100 words most frequently misspelled by elementary school children was compiled by Leslie W. Johnson of Superior, Wis. Another study was made by Thomas Clark Pollock ("College English," Nov., 1954) representing words commonly misspelled (100 or more times) by college students.

A comparative list follows:

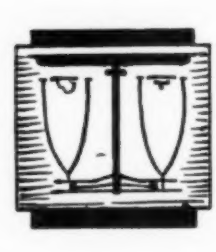
Elementary School Children

their	running	something	know
too	believe	named	decided
there	little	came	friend
they	things	name	when
then	him	tried	let's
until	because	here	mother
our	thought	many	another
asked	and	knew	threw
off	beautiful	with	some
through	its	together	bought
you're	went	swimming	getting
clothes	where	first	going
looked	stopped	were	course
people	very	than	woman
pretty	morning	two	

College Students

their	definite	describe	than
they're	definitely	benefit	then
there	definition	benefited	principle
too	define	beneficial	principal
two	separate	precede	choose
to	separation	referring	chose
receive	believe	success	choice
receiving	belief	succeed	perform
exist	occasion	succession	performance
existence	lose	its	similar
existent	losing	it's	professor
occur	write	privileges	profession
occurred	writing	environment	necessary
occurring	writer	personal	unnecessary
occurrence	description	personnel	

★ ★ ★ ★ ★



You Can Depend on the GENATRON

● THE MODERN ELECTROSTATIC GENERATOR

THE CAMBOSCO GENATRON serves not only for classical experiments in static electricity, but also for new and dramatic demonstrations that are not performable by any other means. It exemplifies a modern method of building up the tremendously high voltages required for atomic fission, for nuclear research, and for radiation therapy.

Entirely self-exciting, the GENATRON cracks into action at the snap of the switch —whose only function is that of starting the motor drive. No auxiliary charging method is employed. Hence, despite an output measured in hundreds of thousands of volts, no hazard is involved, for the operator or for the observers.

An Output of 250,000 Volts — or More!

THE CAMBOSCO GENATRON is designed to deliver, in normal operation, a discharge of the order of 250,000 volts. That figure, a conservative rating, is based on many trials conducted under average conditions. With ideal conditions, a potential difference of 400,000 volts has been achieved.

Modern Design— Sturdy construction and ever-dependable performance distinguish the GENATRON from all electrostatic devices hitherto available for demonstration work in Physics. This powerful, high-potential source, reflecting the benefits of extensive experience in electrostatic engineering, has absolutely nothing but purpose in common with the old fashioned static machine!

NO FRAGILE PARTS—Durability was a prime consideration in the design of the GENATRON which, with the exception of insulating members, is constructed entirely of metal.

The only part subject to deterioration is the charge-carrying belt, which is readily replaceable.

NO TRANSFER BODIES—In all conventional influence machines, whether of Holtz or Wimshurst type, electrical charges are collected and conveyed (from rotating plates to electrodes) by a system of "transfer bodies." Such bodies have always taken the form of metal brushes, rods, button disks or segments—each of which, inevitably, permits leakage of the very charge it is intended to carry, and thereby sharply limits the maximum output voltage.

It is a distinguishing difference of the GENATRON that electrical charges, conveyed by a non-metallic material, are established **directly upon the discharge terminal.** The attainable voltage accordingly depends only upon the geometry of that terminal and the dielectric strength of the medium by which it is surrounded.

Unique Features of the CamboscO Genatron

DISCHARGE TERMINAL Charges accumulate on, and discharge takes place from, the outer service of a polished metal "sphere"—or, more accurately, an oblate spheroid.

The upper hemisphere is flattened at the pole to afford a horizontal support for such static accessories as must be insulated from ground. A built-in jack, at the center of that horizontal area, accepts a standard banana plug. Connections may thus be made to accessories located at a distance from the GENATRON.

CHARGE-CARRYING BELT To the terminal, charges are conveyed by an endless band of pure, live latex — a CamboscO development which has none of the shortcomings inherent in a belt with an overlap joint.

DISCHARGE BALL High voltage demonstrations often require a "spark gap" whose width can be varied without immobilizing either of the operator's hands.

That problem is ingeniously solved in the GENATRON, by mounting the discharge ball on a flexible shaft, which maintains any shape into which it is bent. Thus the discharge ball may be positioned at any desired distance (over a sixteen-inch range) from the discharge terminal.

BASE...AND DRIVING MECHANISM Stability is assured by the massive, cast metal base—where deep sockets are provided for the flexible shaft which carries the discharge ball, and for the lucite cylinder which supports, and insulates, the discharge terminal.

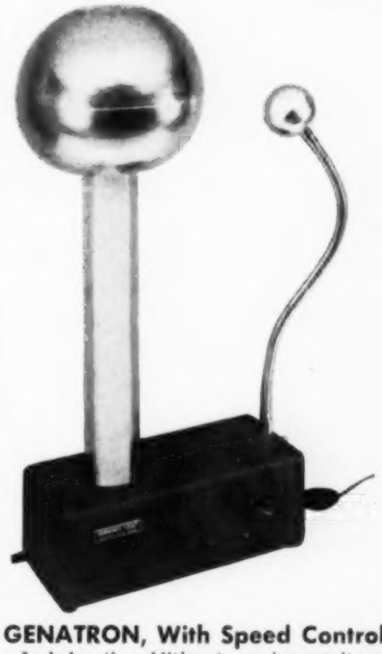
The flat, top surface of the base, (electrically speaking), represents the ground plane. Actual connection to ground is made through a conveniently located Jack-in-Head Binding Post. The base of the Genatron encloses, and electrically shields, the entire driving mechanism.

PRINCIPAL DIMENSIONS The overall height of the GENATRON is 31 in. Diameters of Discharge Ball and Terminal are, respectively, 3 in. and 10 in. The base measures $5\frac{1}{4}$ x 7 x 14 in.

GENATRON, With Motor Drive

Operates on 110-volt A.C. or 110-volt D.C. Includes: Discharge Terminal, Lucite Insulating Cylinder, Latex Charge-Carrying Belt, Discharge Ball with Flexible Shaft, Accessory and Ground Jacks, Cast Metal Base with built-in Motor Drive, Connecting Cord, Plug, Switch, and Operating Instructions.

No. 61-705 - - - - $98.75



GENATRON, With Speed Control

Includes (in addition to equipment itemized above under No. 61-705) a built-in Rheostat, to facilitate demonstrations requiring less than the maximum output.

No. 61-708 - - - - $109.00

No. 61-710 Endless Belt. Of pure, live latex. For replacement in No. 61-705 or No. 61-708 .... $3.00

CAMBOSCO SCIENTIFIC COMPANY

3739 ANTWERP ST. • BRIGHTON STATION

BOSTON, MASS., U. S. A.